MODELLING IN "OOO" GAUGE

Some Practical Suggestions

by

E. F. Carter

LONDON

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PREFACE

ALL DOWN THE AGES MAN HAS BEEN STRIVING TO accomplish the impossible. Not always did he make a conquest, but he was the better man for trying.

In 2-mm. scale railway modelling exists yet another example of a determined effort being made to do the seemingly impossible, but in this case, as time has proved, the achievement was far from impossible, for the problems were by no means so insuperable as they appeared at first sight.

Those who already follow " OOO " will, no doubt, at the present time feel that they are " ploughing a lonely furrow," but the numbers of adherents to this scale are slowly but surely growing, and it only needs an enterprising trade firm to place an electric mechanism and wheels on the market, to bring followers in their thousands into this practically unexplored model railway field.

To those who are inclined to scorn 2-mm. scale I would say that 25 years ago, $3\frac{1}{2}$ and 4-mm. scales were subjected to the same ridicule, but have since more than proved their eminent practicability ; even eventually challenging the well-rooted " O " gauge in the model railway field. In fact, the same story could also be told of the latter scale, as it existed half a century ago.

For those whose primary interest in model railways lies in their operation, or those whose expansive plans are limited by considerations of financial outlay, " OOO " has everything to offer, with but few drawbacks ; whilst those who have " served their apprenticeship " in " OO " scale, will find many of the " OOO " techniques precisely similar—but half the size ! Materials are cheap, and used in microscopic quantities, whilst the power-supply, signalling and control systems used are precisely the same as those used in the larger scales.

In this little volume I have endeavoured, not only to record some personal work in " OOO " gauge, but to integrate the gruelling exploratory work which has already been accomplished in carrying into effect the realisation of this scale as a workable proposition.

ERNEST F. CARTER,
Warlingham.

INTRODUCTION

IT WAS OVER 25 YEARS AGO THAT MR. A. R. WALKLEY made the first outstanding effort in extremely small scale railway modelling, when, working to the then unprecedentedly small scale of 2 mm. to the foot, he produced a beautiful little model of an 0-6-0 Johnson tender locomotive.

This engine, which was, at the time—and for no particular reason—generally regarded as the smallest scale limit of workability, created a furore when it was shown at a Wimbledon (Surrey) Model Railway Club exhibition in 1927, where it worked non-stop for three days from 3 p.m. until 10 p.m., and seemed none the worse for such a gruelling test.

It ran on 2 volts, and, taking about $\frac{3}{4}$ ampere, it hauled comfortably a load of $1\frac{1}{2}$ lb., being very controllable at very slow speeds and yet capable of a maximum speed of about 50 scale miles per hour.

The gauge of the track upon which it ran was $\frac{3}{8}$ in., and was electrified on the now well-known "two-rail" principle, and consisted of brass strip of 3/64 in. × 1/64 in. section.

By way of comparison with "OO" motors, the armature of the motor was $\frac{3}{8}$ in. in diameter, had three poles, and was wound with 65 turns of No. 40-s.w.g. wire on *each* limb. The commutator was $\frac{1}{8}$ in.

in diameter, and was of built-up construction with mica-insulated slots.

Three years later, in 1930, there was exhibited at *The Model Engineer* exhibition a very remarkable working model of a Southern railway 0-4-4 tank locomotive which ran on a track of no more than $\frac{1}{4}$ in. gauge. This tiny locomotive, built by Mr. Leonard R. E. Beale—who built it as a recreation from his professional duties as a saxophone player—had an overall length of $2\frac{1}{16}$ in., and was powered by a tiny motor housed in the boiler. Its extremely small size and the delicacy of its working parts did not, however, suit it for continuous running.

The most amazing thing was, that towards the end of the exhibition a letter arrived from a North London watchmaker who stated that he had built a working model engine only half as large as Mr. Beale's effort—and powered by clockwork! It would seem that this $\frac{1}{8}$ in. gauge locomotive must still hold the record for the smallest "smallest."

These amazing pioneering efforts go to show that, whilst smaller scales than 4 mm. to the foot were practical propositions, yet more than 20 years later, the followers of the only "smaller than 'OO'" scale —2 mm. to the foot—are still to be counted almost on the fingers of one's hands. Why should this be the case?

In the writer's opinion it is largely due to the fact that the average model railway enthusiast does not possess a lathe, and feels that without this tool it is impossible to contemplate even starting to model in a scale for which not even a wagon wheel can be pur-

chased ready-made. The construction of track also constitutes a strong deterrent, and so does the motor question.

In a sense, these difficulties do exist in a minor form, but who is there among our fraternity that does not welcome a problem, or who does not get a real " kick " out of trying—and succeeding—in accomplishing the seemingly impossible in model railway construction and operation ?

Largely, these difficulties have been, and are, greatly exaggerated ; and to make confusion worse confounded, imaginary difficulties seem to be created as soon as theorising and pencil-and-paper work are commenced by those unaccustomed to working in the scale. Practically all these hindrances fade into thin air directly one actually starts to produce something, however humble, in the scale. It is, in fact, a case of " an ounce of practice being worth a pound of theory."

Coming now to the case for " OOO," there is no doubt that it is undoubtedly *the* scale for the expression of one's ideas in respect of real railway operational practice. A " OOO " layout will occupy but one-quarter the area of its " OO " counterpart, or conversely, four times as much " railway " can be accommodated in the area occupied by the " OO " layout. Similarly, events happen at one-half the speed at which they take place on a " OO " railway, and the time-distance factor is also affected in the same advantageous ratio.

To assume that the same amount of rolling-stock super-detail can be added to a " OOO " model is,

of course, absurd—and indeed, such finesse is entirely unnecessary to the satisfactory operation of a " OOO " layout, in which the prime consideration is its flexibility and operational possibilities. Train movements generally take the place of rolling-stock detail. It is, therefore, logically impossible, even undesirable, to attempt to achieve both to perfection.

However, the author does not wish to give the impression that moderate detail is not possible in 2 mm. scale, but rather to explain the true reason why this small scale should gain a place in the model railway world by offering as it does almost unlimited scope for sensibly-timed train movements carried out by trains of full prototype length between proportionately-spaced stations, with platforms of prototype length. The super-detail enthusiast has other fields to conquer in the larger scales, if he has not already conquered them. Broadly, the decision to model in " OOO " or not rests chiefly on the choice between " detail " and " realistic operation " ; for any slight crudenesses are more than outweighed by the delightfully railwaylike operational scope of the smaller scale.

From yet another angle, the very fact that all one's purchases are perforce of raw materials rather than prefabricated parts or finished items, reduces the overall expenditure on a layout of a given area ; for, though there is always the temptation, in the larger scales, to purchase ready-made parts which could be home-made if desired, the " OOO " worker is forced to devote himself to the actual production of his models from raw materials purchased or gleaned

from many sources—some of the latter being very unlikely ones.

In further reference to the increased length of run available within small area limits, it may be borne strongly in mind that one scale mile in " OOO " scale is represented by only 34 ft. 6 in., which represents but two runs around the outside of a baseboard having two square yards of area—6 ft. × 3 ft. Consider again that a main-line train of twelve 60 ft. coaches only extend a little over 4 ft. What scope such proportions offer ! Literally, a real railway system on a dining-room table-top.

Broadly, then, there are two distinct ways of setting about " OOO " scale, each of which has its merits and demerits : we may mass-produce rolling stock and track—using the term " mass-production " in its most embracive sense, or we may individually produce select items of stock, putting into them just as much time and care as we please—the matter of cost—which is so prevalent on other scales, hardly entering into the question at all.

Rolling-stock may be solid or built-up, as desired, whilst the simulation of such details as wagon planking and raised coach panelling is quite unnecessary as they are hardly observable in any case ; whilst if the layout is being designed for operational duties such as train marshalling and goods stock sorting, no less pleasure will be gained if the vehicles used are devoid of such microscopic detailing.

As to the question of motive power, this must obviously be electrical. There is no other choice, unless, of course, hand operation is entertained.

In this latter respect, however, the writer feels duty bound to mention that he has derived many hours of extremely interesting train manoeuvring, during which time there gradually grew a queer " track-side " feeling which really gave the impression that " real " railway movements were being made rather than model ones.

The power unit described in the subsequent pages is easily accommodated in either the tender of a tender locomotive or in the tanks of a tank type. The necessity for the design of a " between frames " power unit is hardly as important as it may seem, for it is only those who desire to build models of " old-time " engines who would ever really feel the need for a power unit suitable for low-boilered engine types devoid of tenders or having tenders of insufficient width inside the body. In any case, such types are greatly in the minority, and were not considered worthy of motorising consideration in a scale so eminently operational in its appeal.

Track, that ever-present problem in the larger scales, becomes reduced to producing one's own rail and sleepers, which is by no means the " headache " one might imagine. A quarter of a pound of round brass or copper wire will produce several " miles " of track with a few hundred sleepers extracted from a discarded cocoa tin. In fact, the larder can become responsible for quite a goodly proportion of " OOO " raw materials, and such as is not discoverable there will cost but a few pence.

The system of track electrification very definitely recommended is " stud contact," which dismisses

rolling-stock wheel insulation problems at one strok e This system has been fully discussed elsewhere, but dimensions suitable for " OOO " scale are shown in the appendix to this book.

Weighing up, then, all the pros and cons of 2 mm. scale, it becomes readily apparent that it is the ideal scale in which to work where space is limited, or where operation is to take pride of place, as distinct from super-detail modelling. Moreover, the very fact that nothing can at the moment be purchased, apart from " OO " point and signal motors, leaves no choice in the matter of what shall be purchased and what shall be made ; for the only things obtainable are what might be termed "raw materials," and these are very cheap, a little expense furnishing the wherewithal for a very large " OOO " railway.

For those of the fraternity whose chief interest lies in the construction of either moderate or super-detail rolling-stock, " OOO " does not offer such a brilliant field for the display of their skill ; for, apart from the extremely minute and meticulous work involved, it can honestly be said that even if fitted, super-details could not be seen without the aid of a magnifying glass, and would find no place on a forth-right working " OOO " gauge model railway layout. The final choice, however, rests with the reader.

CHAPTER ONE

MODEL RAILWAY TRACK HAS ALWAYS BEEN AN ITEM OF considerable expense, whatever the scale of the layout, and as the working scale becomes smaller, the builder often gives way to the temptation of laying more and more trackage in the increased area offered. This mistake usually leads to the ultimate production of a very extensive layout at the expense of poorly-built rolling-stock, or at least a poor selection of that vital necessity to a railway. However, when thinking in terms of "OOO," this state of affairs does not—indeed, cannot—exist ; for 2 mm. scale track is as yet commercially unobtainable, and hence has, perforce, to be home-made as required.

Fortunately, the materials required are extremely cheap and are available everywhere in the country. The raw material used for the rail is nothing more complex than brass wire, which can either be drawn or rolled into the correct rectangular section at home ; and the sleepers are cut from thin tinplate from a no more expensive source of supply than that provided by a half-pound cocoa tin, which will provide enough for 10 ft. of track !

Rail section, when reduced to terms of "OOO," actually becomes $\frac{1}{2}$ mm. $\times$ 1 mm., but, bearing in

mind that it has to be soldered directly on to the sleepers, it is best to make up for the absence of chairs by making the rail height 1½ mm. If this is not done, it will be found that the track looks too "flat" and near the ground level, especially when thin sleepers are used in conjunction with it. Moreover, the slight addition to rail height materially assists in the preservation of a good even rail surface by the additional strength the larger section provides. Point blades made from ½ mm. × 1½ mm. rail are less prone to get bent out of shape under traffic conditions.

Taking then the ½ mm. × 1½ mm. rail as a basis, round brass or copper wire will be required which can be shaped to this section; and No. 18-s.w.g. will answer nicely, providing as it does sufficient material in its cross-section area to produce a rail 1½ mm. deep and almost ¾ mm. in width—actually .813 mm. × 1.422 mm. (No. 17-s.w.g. × No. 21-s.w.g.). If dead scale rail is required, and the lack of chairs is to be ignored, then No. 20-s.w.g. wire should be used which will produce a rail .559 mm. × 1.016 mm. (No. 19-s.w.g. × No. 24 s.w.g.). The choice of size is left to the reader; the method of rail production is the same in either size.*

As it is impossible for the amateur to attempt to make a proper wire-drawing plate, some simple method must be devised which will effectively alter the section of the wire from round to rectangular; and an easy way of achieving this end is by using the little device shown in Fig. 1. It will be seen that

* 1 lb. No. 18 brass wire = 150 ft. = 75 ft. track run = a scale 3,800 ft. = ¾ mile.

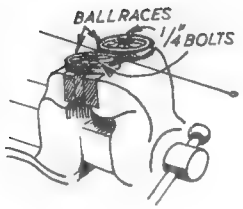


Fig. 1. Wire-drawing

it is, in effect, a small rolling mill consisting of two $\frac{1}{4}$ in. or $\frac{3}{8}$ in. steel bolts about 2 in. long, on each of which is placed a 1 in. or $1\frac{1}{2}$ in. ball-race. The lower ends of the bolts are then gripped in the vice-jaws as shown, so that the distance between the adjacent surfaces of the rollers is slightly less than the diameter of the wire being rolled. The ball-races need not be new, and can generally be obtained from the local garage or war disposals shop.

The heads of the bolts must be pressed firmly down on to the race centres, so that the latter will not rise away from the surface of the vice-jaws, as close contact here is very important. If the ball-races are examined, it will be observed that both edges of the outer ring

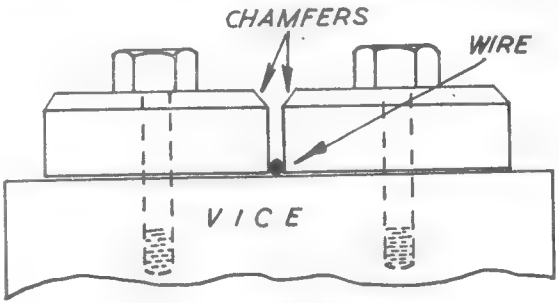


Fig. 2. Wire in ball-race

are not rounded or chamfered, one having an almost dead-sharp corner. Care must be taken to see that the rounded corners are placed uppermost, so that pressure may be brought on to the wire as it passes through the rollers, right down to their extreme edges where they touch the surface of the vice-jaws. (Fig. 2.)

The leading end of each length of wire to be rolled should be hammered into a spade-shape, so that it may be easily passed between the rollers, which are, of course, set closer together than the original diameter of the wire.

The wire rolling should be done with a strong, steady pull, without any semblance of a "snatching" movement, working with 3 ft. lengths of wire and well smearing the vice-jaws between the rollers with tallow or dripping-fat. Oil is ineffectual as a lubricant for brass wire though it is quite good with copper.

If only a very light vice is available, it may be found necessary to link the bolt-heads together, so that they do not open apart in the vice whilst the rolling is in progress. There are several ways of doing this linking, but perhaps the simplest is that shown in Fig. 3, in which it will be seen that an adjustable bracing is obtained by drilling 2-B.A. clearance holes through the heads and passing through them a length of 2-B.A. rodding, or a 2-B.A. steel bolt with a nut. If this top link is used, half a turn should be made on the nut between each successive roll through the mill.

To roll, the spade end of the wire should be squarely gripped with the pliers, and no attempt should be

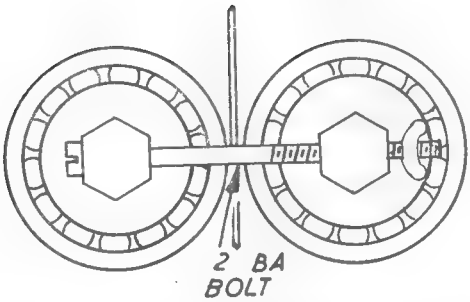


Fig. 3. Wire-rolling

Fig. 4.
Section of wire

made to effect too great a crushing at one passage through the rollers. On an average, working with No. 18-s.w.g. soft brass wire, about six times through will produce the correct section of rail, the rollers being gradually brought closer together between each rolling, as has already been mentioned.

Upon consideration it will be realised that this rolling process merely flattens the wire from a round to the section shown in Fig. 4 ; in which the rounded parts *A* and *B* have not been surfaced at all. If, when rolling, the wire is turned over at each successive roll (giving two rollings to each setting of the rollers) both *A* and *B* will be surfaced to a great extent by coming into contact with the surface of the vice-jaws.

In actual track making, the writer has found that if a final planishing-up of the rail surface is made with an 8 in. smooth-cut file *after* the track has been assembled, all is well. One has to bear in mind that no "OOO" track is strong enough to be moved after it has been once fixed to the layout baseboard, and any amount of final surfacing and levelling has only to be done once and for all.

Returning to the rolling process once again, it may be mentioned that if the ball-races are not available (which is extremely unlikely), the wire may be "drawn" between the smooth shanks of the bolts, from which the heads must be cut to enable them to be mounted closely together in the vice. If plenty of fat is used as a lubricant, and not too great a crushing is attempted at each draw, a very effective rail section will be produced.

A word as to the bolts used. In the drawing mill, hard steel bolts of not less than $\frac{1}{2}$ in. diameter should be used; the larger their diameter the easier will be the work and the smoother the finished article, though the roller mill considerably reduces the work.

When using the rolling mill it will be found that though soft and malleable brass wire is used at the outset of the process, at the end of the shaping the wire will have become toughened, springy and straight; in fact, No. 18-s.w.g. bare *copper* wire will become so hardened by the rolling that it is quite strong enough to be used as "OOO" rail, in case brass wire is unobtainable.

It may be found of great assistance, when rolling brass wire, to coil up the 3 ft. lengths after the first four rollings, and heat them to red heat in a gas-fire. This will anneal the metal and soften it again, but though the rolling or drawing work will become lessened thereby, the finished rail will not be so hard and springy; so try to get through the entire shaping process with plenty of lubricant and no annealing.

If a fair quantity of track is being made up, it is best to rough-straighten about 15 or 20 yard lengths

of wire, and after spade-ending them, pull them all through once, following this by subsequent pulls. By this method of working any variation of pressure between the rollers (and thus difference of final section) will be avoided.

The production of a web on the rail-section is easily possible if shaped, hardened steel rings are turned up and slipped over the ball-races ; but this finesse is impossible without the use of a lathe. Some form of web can be " ploughed " out by dragging the rail between two cutting edges which may be ground to shape from broken pieces of hacksaw blade, but there will be produced a very " stringy " appearance, and there is a great tendency for the process to distort the evenness of the rail lengths ; once twisting has taken place, it is almost impossible to correct it and produce a nice flowing rail.

The " mass " production of " OOO " sleepers, $\frac{11}{16}$ in. $\times$ 3/32 in., is quite an easy matter, and, as has been mentioned, an empty half-pound cocoa tin will provide sufficient for 10 ft. of track. The bottom of the tin should first be removed with the aid of a fine-cut hacksaw. Tin-snips are not suitable, as they distort the metal very badly. The open sheet cylinder thus produced should then be cut down by the side of the seam, the latter being afterwards entirely removed, and the sheet of metal carefully opened out flat. If a rubber-rollered domestic wringer is available—and an opportune moment can be found !—the sheet can be perfectly flattened by two or three passages through the rollers. The sheet is then shear-cut into $\frac{11}{16}$ in. wide strips, the waste dis-

carded, and the strips again snipped into 3/32 in. wide sleepers, which can then be individually planished flat with a light hammer, using a domestic iron as an anvil.

All is now ready for track-making, which anyone already conversant with home-made track construction in "OO" scale will not find very difficult.

Many different methods have been tried, one enthusiastic follower of the scale* using $\frac{1}{4}$ in. × 1/32 in. brass ribbon, which is inserted in 1/32 in. × $\frac{3}{16}$ in. deep slots in a five-ply baseboard ; sleepers being made of blotting-paper appropriately stained. It is claimed that this type of track is very satisfactory, looks realistic, and works up very well into points.

Another scheme† consists of soldering a more scale-sized rail to the sides of fine brass pins driven in to correct gauge with a simple locating jig. If this work is carried out on three-ply wood, the top ply can be partially removed to give a raised sleeper effect.

Of these two systems the writer prefers the latter for two-rail working, but used with the blotting-paper sleepers of the first idea, owing to the difficulty of getting three-ply of anything like standard thickness.

The result of the combination is shown in Fig. 5, where it will be seen that the rails are soldered to pins at every fifth sleeper, the intervening three sleepers being dummy. This produces an amply-strong and rigid track for all normal purposes.

The making up of point and crossing work has a great deal of "OO" gauge technique in it, but the work is more delicate, the limits of error are finer,

* J. W. Charlton, Esq. † Evolved by the late L. S. Mitchell, Esq.

and greater attention has to be paid to gauge and check-rail measurements than are necessary in the larger scale. Once, however, the theoretical difficulties of working in " OOO " have been mastered, there is no real reason why the scale should not have many hundreds of enthusiastic adherents ; for after all, practically all the difficulties are supposed, not real ones.

If copper wire is being used for rail material, and point blades are being formed from it, it will be found of great assistance if several lengths of rail are soldered down on to a piece of $\frac{1}{2}$ in. $\times$ $\frac{1}{8}$ in. hard brass strip, and the taper of the blades all filed off together. Perfect accuracy is obtained by this simple method, and they can be unsoldered after having been shaped. As little heat as possible should be used during soldering, so that the rail is not softened too much.

Track may also be made with thin tin-plate sleepers, and this construction is very strong indeed. Moreover, point and crossing work is much less of a problem. Such track is suitable for either third-rail or stud-contact electrification, of which the latter system is to be preferred. The reason for the choice is that, owing to the light weight of the locomotives (only some 50 grammes), a snag becomes apparent by reason of the

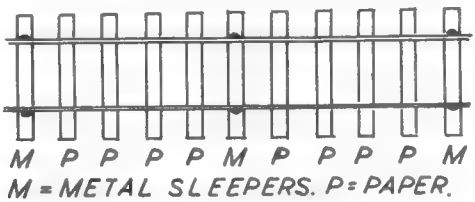


Fig. 5. Track-making

upward pressure of the normal third-rail shoes reducing the effective adhesion weight available in the engine, any high spots in the third rail causing wheel-slip. With either " two-rail " or stud contact, no downward springing of collectors is necessary, and consequently there is not any upward pressure on the locomotive itself. A weighted shoe is all that is required for steady current collection in " OOO " stud contact, the former being devoid of any upward counterthrust. Collector springs are very definitely taboo in " OOO " scale.

A pleasant freedom of running will also be observable when either " two-rail " or stud contact are used, and the problems attendant on the accurate lining up of the third rail are non-existent. The free-running quality so noticeable is in part due to the absence of spring-pressure on the third rail, and is more apparent with " two-rail " than with stud contact ; but owing to the uncertainty of the rolling contact provided by ""two-rail," there is no doubt that stud contact gives more stable running at low voltages, although at the expense of slightly additional friction.

Those readers who do not think it is worth while to go to the trouble of drawing a rectangular section rail, but imagine that round wire will be good enough for the job, will be well advised to reconsider their choice. Wheels with profiles designed for a bull-head type of rail will not give successful running on round-topped rail. The same snag is experienced when scale or semi-scale " O " gauge wheels are run on tinplate track. Derailments are frequent, adhesion poor, and running friction greatly increased ; moreover, pointwork in round section rail is well-nigh impossible

of production with any degree of accuracy.

As the majority of newcomers to "OOO" gauge will have had some working experience in "OO" gauge, it is not considered necessary to deal at length with the production of straight and curved track in the smaller size, for the methods used are precisely similar to those which are so well known in the larger size. However, a simple straight-track construction jig is shown in Fig. 8 which is both simple to make and effective in use.

Working in "OO" gauge is a good school for "OOO," but greater care *must* be taken in track building. Shoddy work is hopelessly inadequate, and will only produce poor-running track, which will cause endless annoyance and disappointment. To say the least, as much care must be expended on "OOO" work as that given to "OO" if anything like success is to be attained.

Plus and minus limits between rail and wheels must be kept as fine as possible, working these limits in opposition to each other. Thus there must be a plus limit on flange thickness but a minus limit on check-rail gaps, a minus limit on wheel back-to-back measurement but a plus limit on check-rail gauge, and so forth, so that what one "gains on the swings one loses on the roundabouts."

A list of the generally-accepted standards in use for "OOO" gauge is appended at the end of this handbook, and the reader will do well to work to them in the interests of standardisation; for, sooner or later, there will be a manufacturer of scale models and parts in 2 mm. scale who will be prepared to

create and satisfy a market and justify the cost of "tooling up" in the new scale. When this takes place, it will be very advantageous to all concerned if a set of known working standards are available, without which there are few firms with the courage to tackle such a formidable task. Lack of standards is one of the most powerful deterrents to embarking upon such a venture. When, however, such trade interest does materialise, the "OOO" gauge picture will be completely altered for us all. In the meantime, home construction is the only solution to production.

CHAPTER TWO

WHEN DROPPING DOWN TO A NEW AND SMALLER SCALE such as 2 mm., the amateur is faced with many difficult problems because everything must be made "from scratch," from sleepers and wheels to motors and coach fittings; and not the least of these teasers is the production of wagon, coach, and locomotive wheels.

Within the average limits of amateur possibility there may be said to be three different methods by which non-spoked wheels may be made: (a), by turning from brass rod in the simplest of lathes, (b), by casting in a simple three-piece mould from lead or white metal (including Rose's metal, Wood's metal, and dental alloy), and (c), by cold-pressing lead or other ductile alloy in a die, using the vice or hammer and anvil as the source of pressure.

At the risk of being accused of reiteration, the writer would again stress the point that, in 2 mm. scale, the difference of appearance between a spoked and a non-spoked wagon-wheel is negligible. The two types have to be seen running beneath the same vehicle before the truth of this statement will be believed. Moreover, the great charm of the small scale is the freedom of operation and scope for layout expansion

which it offers, rather than the opportunity it provides for meticulously accurate details. After all, one cannot have it both ways !

Dealing first with the production of simple disc wheels which will be equally suitable in design for either wagons or coaching stock, it is primarily essential that they be made in fair quantities from easily obtainable material machined in a simply-arranged " lathe " of sorts. Those readers in the possession of a regular lathe are in a position to skip many of the following instructions, and they will, no doubt, formulate a way of their own to turn 11/32 in. or $\frac{3}{8}$ in. brass rod into three or four dozen wagon or coach wheels.

The first job becomes one of suitably mounting the drill brace in a horizontal position in the vice, so that it may do duty as a lathe, and Fig. 6 shows how this may be done, although it is impossible to state that any and every hand-brace will be capable of being mounted so simply ; the general idea is depicted, however.

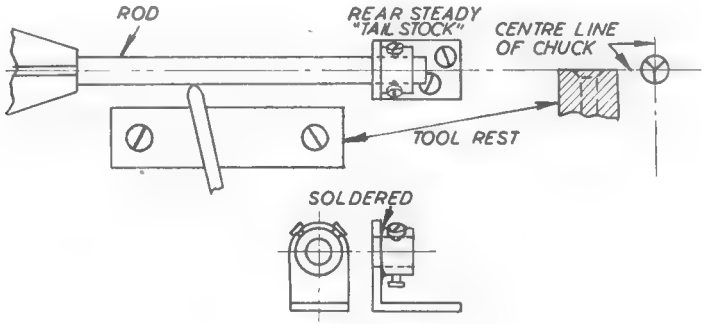


Fig. 6. Positioning drill brace

The tool-rest is made from a block of hardwood shaped as shown in the inset sketch, and the rear steady bearing is made with the aid of a domestic angle-bracket to which a brass collar is soldered and fitted with three tightly-fitting screws, as shown. The top of the tool-rest must be at the same height as the centre-line of the chuck, and the central bearing-hole in the end steady must be in a similar relationship. Both tool-rest and steady are, of course, screwed firmly down to the bench in correct alignment, vertically and horizontally with the drill-brace axis.

For wagon and coach wheels, brass rod 11/32 in. in diameter will be used, and it is a great advantage if the drill chuck will receive this diameter of stock. If it does not, the only thing to be done is to have several 3 in. lengths of 11/32 in. rod turned down to 5/32 in. at one end to enable them to be gripped in the chuck of the drill.

The bar must first be turned up into sections, cutting away metal as shown in Fig. 7, and leaving projecting portions of slightly greater thickness than that required for the final wheels. This thickness may be varied within limits, according to the accuracy of the track upon which the wheels will have to run. In appearance, there is not much to be gained by a very thin wheel, though track must be much more perfectly made if it is to run without constant derailments. In practice, 1½ mm. is quite a good working dimension, and the embryo wheels should thus be made about 2 mm. thick, to allow for future working and cleaning up.

When the whole length of rod has been thus treated,

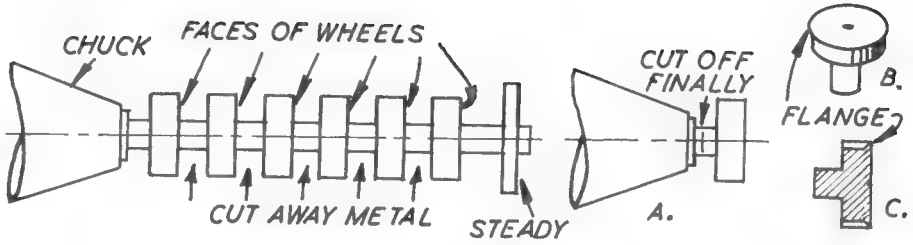
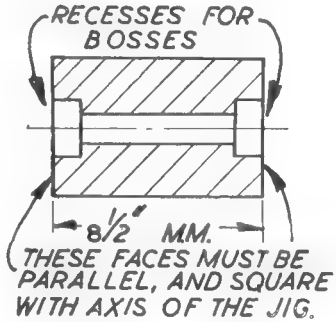


Fig. 7, A, B & C. Cutting out wheels



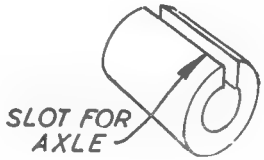


Fig. 8. Spacing jig

it should be removed from the drill-chuck and placed in the vice between pieces of sheet aluminium or fibre (to prevent it being bruised), and each "wheel" with its rear stub projection cut from its neighbour with an "Eclipse" saw fitted with a fine-cut blade. This will produce a number of studs, each representing an ultimate wheel.

Each stud is then individually inserted in the drill-chuck, and is reduced to the correct tread diameter, leaving part of the surface not reduced in diameter to form the flange. (Fig. 7A.) Care must be taken to see that each wheel is made accurately to the same tread diameter, as this can neither be reduced nor increased at a later stage in production.

When all the studs have been thus treated, they are again chucked and their flanges reduced until they are about $\frac{3}{4}$ mm. proud of the treads. No attempt should at this stage be made to round off the edge of the flange.

Next the tool-rest is brought round so that it lies across the face of the drill-chuck. The studs are then rechucked one by one, and the faces of the wheels dished to form a rim and central boss. The actual accuracy of this part of the work has no bearing upon the running or appearance of the final wheels.

Before removal of each wheel from the chuck, a diamond-shaped graving tool should be used to produce a central dimple or "pop" in the wheel-face, into which a drill can be started to produce a central hole. The size of the drill used is, of course, determined by the size of the axle to be used. A good size is No. 18-s.w.g. silver-steel rod, which makes a force-fit

into a No. 55 drill-hole.

When drilling these holes the drill should be held in a small tap-wrench, and should be presented to the work in the chuck whilst the latter is revolving. Do not attempt to drill these holes in the ordinary fashion (with the wheel held in the vice) they will only be made eccentric by that method. Incidentally, the drill-hole need not pass right through wheel and stub, but only through the former.

The saw is then brought into use on each successive stud, and the projecting piece is cut through at a distance of about $\frac{1}{16}$ in. from the back of the wheel, thus producing a nice heavy boss which will ensure freedom from wobble when the wheel is mounted on its axle. Should the central hole not have been pushed through far enough, its depth should be finally checked before cutting the wheel from the stub in the chuck. The hole cannot accurately be deepened afterwards.

A piece of axle wire should now be mounted in the chuck, and each wheel in turn gently pressed on to its axle, face of wheel towards the chuck, whilst the back of the wheel is cleaned up—flange-edge included—with "blue-back" or very fine emery-paper. This process finishes the wheels, and now for mounting them on their axles.

The axle material should be carefully *sawn* into $13\frac{1}{2}$ mm. pieces, and each end of each piece should be rounded and polished in the "lathe." This length is for wagon wheels, with outside axleboxes; with inside boxes the axle length will naturally be less.

Before attempting to force the wheels on the axles, a simple spacing jig must be made, shown in Fig. 8.

Extreme accuracy is essential in the making of this vital tool, and the reader would be well advised to have one turned up at the nearest shop to the dimensions shown. With a track gauge of 9½ mm. the distance between backs of wheels should be 8½ mm., this allowing for a total wheel thickness of 1¼ mm. If a thicker wheel is being used, then the back-to-back dimension will be proportionately reduced. Flange thickness and flange depth are dimensions which can be set by the reader if desired, but in any case, the standards decided upon *must* be used for every wheel on every vehicle if successful running is desired.

It will be appreciated that, at an earlier stage of production, it is easily possible to reduce the overall thickness of the wheels to any logical desired dimension without hampering the scheme of operations suggested for production. However, it must be remembered that the thinner the wheel and the shallower the flange on it, the more perfect must the track be.

Now to use the jig. First, a clearance hole for the axle is drilled in the centre of a substantial block of brass or iron (the writer used the rear anvil of the vice) to the same depth as the axle is required to protrude from the face of the wheels (this for wagon wheels and wheels for use with outside axleboxes). An axle is then gently tapped through a wheel and into the depth-checked hole until it bottoms therein. Wheel and axle are then removed and a further check made to ensure that the projection is of the correct dimension.

If all is well, wheel and axle are then inverted over the hole and the other wheel similarly tapped into position. Before the final blows are given, however, the " back-to-back " jig is inserted between the wheels, and a final seating made with the jig in place.

Without removing the jig, an examination should be made to see that there is an equal amount of axle projecting from the face of each wheel. Should this not be the case, and the second wheel fitted allows too much axle to project, then obviously, the depth-gauge hole in the block is too shallow; or vice versa, and this must be altered accordingly.

Wheels made and mounted in this fashion should run truly when tried on the surface-plate, and, owing to the projecting boss at their rear, they will not get out of truth very easily, even with fairly rough handling.

Coach wheels of the " pressed steel " type can be made by the same process, the three holes in the disc being marked by means of alignment taken from the three jaws of the drill-chuck. These holes must, of course, be drilled before mounting the wheels on their axles.

This process of wheel-production may seem rather involved, but the writer has found it quite simple and satisfactory, particularly when one can find a friend to do the turning of the drill-brace handle, whilst one concentrates on the shaping of the wheel blanks.

Another excellent process for the semi-mass production of coach or wagon wheels makes use of pressure on a solder or lead blank of correct size, and for this method a die of brass must first be made in which

to shape the wheels. This can be produced at home if a fair-sized wheel-brace and suitably-large drills are available.

However, it is extremely important that the top and bottom surfaces of the brass die-block A (Fig. 9) are perfectly parallel, and that the 11/32 in. or $\frac{3}{8}$ in. hole through its centre is absolutely vertical—in line with the axis of the bar. Therefore, it is essential, if a regular lathe is not available, to have this block turned up professionally (perhaps at the local garage) to the dimensions shown, and the central hole drilled of the same size as that required for the treads of the wheels.

The No. 55 hole (*H*) should be drilled in the end of the die-plunger, after the latter has been turned to a smooth running fit in the die-block. It should fit neither too tightly nor too loosely, but must move freely and without shake, when oiled.

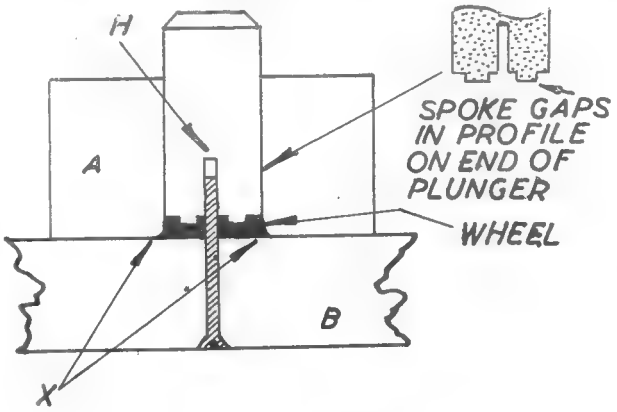


Fig. 9. Die-block

A really solid metal base (*B*) is essential upon which to operate the press. The writer once again used the flat part at the rear of the vice for this purpose, and a hole about $\frac{1}{8}$ in. deep was drilled therein with a No. 56 drill. Into this a $\frac{3}{4}$ in. length of No. 18-s.w.g. silver-steel wire (previously hardened by heating to a red heat and quenching in water) was driven, great care being taken not to bend the wire in the process.

The pin must then be tried for its fit into the small central locating hole in the die-plunger, and if it is at all tight, must be carefully reduced in diameter with fine emery-cloth. Do not tamper with the hole in the die-plunger, which must drop over the pin until its lower face touches the baseplate. When this fit has been attained, the die-block (*A*) can be dropped over the plunger. The whole assembly should lie perfectly flat on the working baseplate.

Assuming that die and die-block have thus been made and fitted together, it now remains for the reader to shape up the end of the die so that it will press the required pattern on the face of the wheel being made. The recess necessary to form the wheel flange must also be made in the underside of the die-block at *XX*.

The lower end of the die-plunger (*P*) should first be shaped, and the details to be cut thereon depend upon the type of wheel to be produced. If a disc-type wheel is desired, then the die must be mounted in the drill-lathe, and the profile desired on the wheel must be cut in reverse on the end of the die.

A close study of the impression made by the face of a 4 mm. scale wheel in Plasticene will show better

than anything just what is required.

It is a good plan to take an impression of the end of the die as the work proceeds, for by this " running commentary " too much metal will not be removed. Once this error has been made, metal cannot be replaced on the die-face !

Wagon-type wheels may be given a spoked appearance by treating the end of the die-plunger as shown in Fig. 10, and cutting eight spokes in recess across the raised portion which is left after turning down the periphery to produce the rim, and after turning out the centre to form the wheel boss.

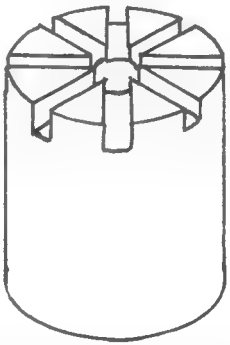


Fig. 10. Die-plunger

Here again, the study of an impression of a 4 mm. scale spoked wagon wheel will be a great help, for working a pattern in metal in reverse is not quite so easy at it may seem.

As the recessed "spokes " are being cut, trial pressings should be taken, so that the bottoms of the slots (faces of the spokes) may be nicely rounded and moulded into both hub and rim. This will entail some

careful work with the extreme tip of a round needle-file. And here a word of warning may not be out of place :—Do not put undue pressure on the file, for once its tip is broken off, the tool is utterly useless for the job in hand.

When complete satisfaction has been obtained with the final shape of the Plasticene impression of either type of wheel-face, and not before, the job of undercutting the lower edge of the large hole through the die-block (*A*) may be commenced. This chamfering must be done very charily, for if too much metal is once removed, a crude flange will be produced on the wheels pressed. Either a rose-bit or a moderately-sharp $\frac{1}{2}$ in. drill must be very carefully twisted round by hand with very light pressure, and inspection made at *every* revolution. It must be realised that a very slight bevel on the die-block will produce quite a deep flange on the wheel, so deceptive is this reverse working.

A constant check must be kept during this chamfering work by half-filling the hole in the die-block with Plasticene and pressing down the die-plunger whilst holding the die-block down on to a perfectly level surface. By this means, a trial flange will be produced on the plug of clay, which can be examined critically and any necessary alterations to the chamfer made.

When a satisfactory flange has been produced, a final test of wheel-face and flange may be made by taking a clay disc of approximately wheel thickness and dropping it over the pin which projects from the baseplate. The die-block (*A*) is then carefully centred over the clay pellet and is pressed down on to the

baseplate. The die-plunger is then entered into the top of the die-block, and is gently pressed down until the top of the pin (projecting through the clay) enters the locating hole in the bottom of the plunger. Gentle pressure should then be brought to bear on the plunger whilst, at the same time, the die-block is kept firmly pressed down on to the baseplate. When further downward movement of the plunger is impossible, it and the die-block are raised from the baseplate and the clay wheel is extruded from the die-block by further pressure on the plunger. If the examination of this final test "wheel" reveals perfection, the production of a metal wheel may be considered.

Either solder or lead must be suitably prepared for use in the press, and the scrap or other metal should be cast into a stick of a very slightly smaller diameter than that of the central hole in the die-block (tread diameter). This may be done readily by forming a mould by drilling a suitably-sized hole in a bit of hardwood. From this rod of metal, discs must be cut of the same thickness as that required in the finished wheel, and a No. 55 hole must be made in the centre of each disc ; a simple centring jig being made for the purpose.

The die-press operates as follows : a disc of metal is slipped over the centre pin, the die-block is placed over the disc, resting on the baseplate. The die-plunger is entered into the block and its hole located on the top end of the pin, being then lowered until it rests on the wheel-blank within the press.

A smart blow with a 4 oz. hammer on the top of the plunger whilst holding the die-block firmly

down on to the baseplate should be all the force necessary to shape the front of the wheel and to press out the metal into the flange chamfer. Solder will be found slightly harder to work than lead, but it produces a harder wheel.

Spoked-type wheels require more pressure than disc-types, but experiment and subsequent experience will show just the right amount of force needed in the blow or blows to produce a nice clean wheel.

It is essential that the thickness of the metal blanks used is made standard by measurement with calipers before placing them in the press, as the ultimate thickness and perfection of the wheels are determined by this dimension. The small amount of metal lost on the production of the wheel-face will generally about balance that needed to produce the flange. Trial and error is, however, the best method of determining the correct thickness of the blanks used.

If solder, lead, or the softer grades of white-metal are being used, both die-plunger and die-block can be made of hard brass, which will be quite strong enough if not bruised, dropped, or otherwise roughly handled. If copper is used for the wheels—and it is quite satisfactory—it should be softened before use by being heated to red heat and plunging into water. With copper, iron or steel must be used for both die and die-block.

If desired, solder or lead wheels may be nickel-plated by the process explained elsewhere in these pages. They will thus be given a harder tread and flange. If this is done, they must be threaded by their axle-holes on a slip of wood or other non-metallic

material to prevent the bores of the axle-holes being reduced in size by the deposit of nickel.

The production of true pierced-spoke wheels in wagon size entails very deedy die-sinking, whilst frankly, the finished wheels are almost indistinguishable from those with a " recessed-spoked " appearance, the making of which has been dealt with in this chapter.

Much of the pressure technique is applicable to the casting method of wheel production, which is the only moderately-easy way of making true-spoked locomotive driving-wheels.

Brass rod must be used to form the core of the wheel-mould, and this must, of course, be of the tread diameter of the wheel. Upon the end of the rod must be formed the recesses which will form the rim, spokes and hub of the finished wheel. This part of the mould is used with its shaped end upwards, the wheels being cast face downwards instead of face upwards, as in the pressure-shaping process.

In making a mould, every care must be taken to ensure that each recess therein has a slight taper towards the bottom so that it is not possible for the casting to be locked in the mould, as would be the case if the sides of recesses were either parallel or undercut. This consideration is very important in the design and cutting of the die, and failure to make these allowances will result in the sight of a perfectly good wheel which cannot be persuaded to leave its mould—a very irritating thing to happen.

To cut the required number of spokes accurately in part No. 1 (Fig. 11) of the mould, a card disc about

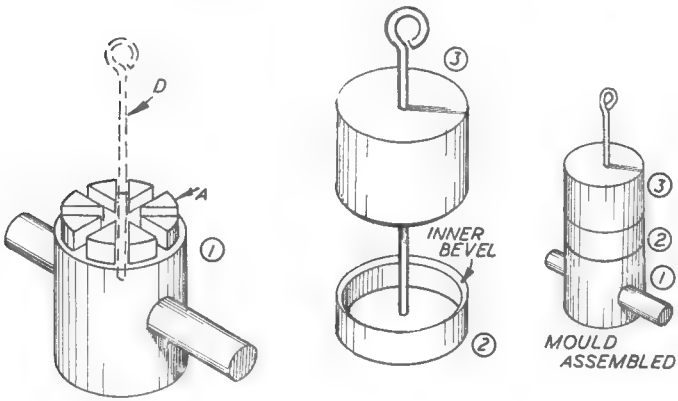


Fig. 11. Mould assembly

three inches in diameter should be carefully divided and pencil-marks made thereon. The end of the brass rod should then be centred on the disc and lines scribed on the metal along a straight-edge joining opposite marks on the card. Filing out proceeds in the same way as previously described, great care being taken not to damage the flats between the spoke recesses.

A shoulder must be turned on part No. 1 where shown, down to which the collar with the flange-chamfer must be pressed. A central hole to receive the end of the axle pin must also be drilled in part No. 1. The diameter of this hole is dependent upon whether insulated wheel-hubs are being fitted for "two-rail" operation. In this case the pin should be about twice the diameter of a normal axle—i.e. about

$\frac{1}{8}$ in. Otherwise the No. 55 pin operating in a No. 54 drill hole will be suitable.

Part No. 3 is merely a cylindrical block with a No. 54 hole drilled through it, which acts as a "lid" to the mould.

A sheet-metal clamp which will allow of the assembled mould being gripped with pliers will be needed, into which the three parts can be placed, and a piece of $\frac{1}{8}$ in. steel rod is passed through a hole drilled diametrically at the lower end of part No. 1 to act as a tommy-bar when the mould is opened after casting has taken place.

In operation, the mould is assembled as shown, a suitably-sized pellet of solder or lead being placed between parts Nos. 1 and 3, and the axle pin inserted where shown. As the mould is heated up, the pellet will melt, and part No. 3 will drop down until its lower surface touches the upper surface of the spoke ridges on part No. 1. Sufficient metal should be used in the pellet to ensure that a certain amount is ejected from the cracks between the parts of the mould, to ensure that the mould is completely filled.

When the mould is cool, it is released from the grip of the clip. The central pin is withdrawn, and part No. 3 lifted off, thus exposing the back of the wheel and its spokes. Part No. 2 is then gripped with the pliers, and part No. 1 withdrawn ; after that the wheel can be pressed out of part No. 2 with a wooden skewer or other non-metallic object.

Do not be disappointed if the first casting is not a perfect success, but examine it carefully. A little logical deduction and observation will soon effect

minor alterations in the mould which will ensure every casting being a success.

Once again, wheels cast in this manner may be nickel-plated as already described to make them harder and better suited to electric traction.

CHAPTER THREE

WHEN ONE CONSIDERS THE COMPARATIVELY LARGE amount of rolling-stock which can be accommodated on even a moderately-sized " OOO " layout, the question of semi-mass-production of wagons and coaches may well be given careful consideration, simply because of the greater scope given by the scale to operational movements, and the increased need for quantities of rolling-stock to make those movements realistically possible.

The actual scheme of coach and wagon body construction follows very closely that used for " OO " gauge, the only outstanding difference being in the use of thinner and frailer materials and although there are kits of parts now available for the construction of wooden glazed coaches, the building of out-of-standard coach types is best carried out by orthodox methods* using thin cardboard or hot-pressed board cemented with tube adhesive, and finally proofed with shellac varnish.

When it comes, however, to the making of wagon and coach underframes, and coach bogies, the story is a very different one. The problems involved in construction are definitely not capable of direct

* See " Building Passenger Rolling-stock," Percival Marshall & Co.

solution by " OO " gauge methods and reasoning. The mere halving of " OO " dimensions is insufficient. Different methods have to be used, and a lower standard of super-detail must be imposed and worked to by reason of the fact that there just is not the physical space upon which to represent those items which are seen and appreciated in the larger scales.

There is another point worthy of notice with regard to these small models. It is that many items of relief and pierced work—which in 7-mm. and 4-mm. scales are deemed to be essential features—become so extremely small in 2-mm. scale that their absence is scarcely noticeable. This is, indeed, very fortunate, for unless he is desirous of becoming a watchmaker, the reader will find his path in " OOO " made much easier by omitting non-essentials, and aiming only at getting the broader " atmosphere " ; and this is, incidentally, easier to achieve in 2-mm. than it is in the larger scales. Operational possibilities, rather than slavish reproduction of super-detail, will be found to give a more permanent enjoyment to the follower of " OOO," for whilst very fine work can become very tedious, model railway operation in any scale *never* loses its interest.

Take for example, the simple wagon solebar with axleguards, of which some dozens of pairs will be

Fig. 11a. Standard 1923, R.C.H.

needed. Fig. 11A shows the standard 1923, R.C.H. metal underframe for a 12-ton wagon reduced to the actual size required for a 2-mm. scale vehicle. It will be seen that such details as the pierced axleguards and springs have become so minute as to be hardly definable, being even less conspicuous when the whole solebar-cum-axleguard unit is regarded in the solid, painted matt black, mounted underneath a wagon.

However, to get down to production methods which can be used for wagon solebar-axleguard units, bogie sideframes, and axleguards for four and six-wheeled stock generally, wagon units have been made by amateurs by die-casting, using built-up laminated dies. In the writer's opinion, such methods are outside the limits of *average* skill and dexterity, and are, moreover, extremely likely to give rise to rather despondent feelings when after many hours of meticulous work with drill and needle-files, a perfect casting is still not forthcoming.

Die-sinking and die-casting is a highly-specialised and very skilled trade, and even in its simpler applications, can produce " snags " without number. Die-casting is *not* the " easy way out " which many would have us believe. If hundreds or thousands of a given item are required, then it is the only rational production method for certain classes of work ; but for runs of two or three dozen, the amount of work put in on the die will not be repaid.

The following method of making solebar-axleguard units will be found more within the limits of average skill, entailing as it does simple shaping and bending work, together with elementary jig-assembly. It is

not the method for the super-detail "fan," but aims at the simple production of any reasonable number of units of scale size and of realistic appearance, upon which wagons can be quickly mounted with a view to "getting something running" in the least possible time.

The general idea is shown in Fig. 12A, where it will be seen that strip metal is cut out and folded to produce the solebar-axleguard, and upon this is mounted—if desired—another sheet cut-out representing the spring and axlebox. Three layers of metal are thus visible, viz. (1) the solebar, (2) the axleguard, and (3) the axlebox-spring. This gives an ample representation of relief, and, when painted matt black, is hardly distinguishable from a die-cast job.

There are many different types of wagons, with different wheelbases, over-headstock lengths, and

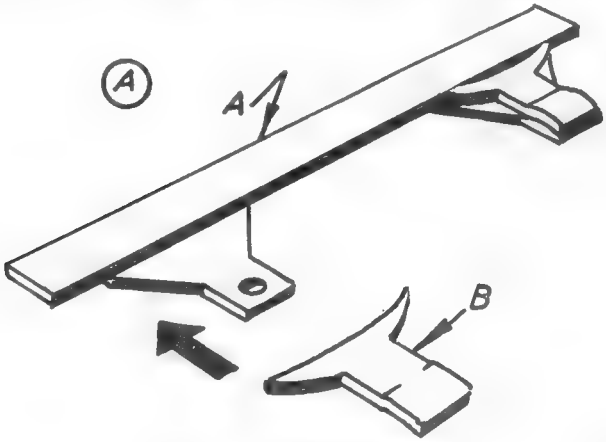


Fig. 12a. Solebar-axleguard

materials used for the solebars ; and four of these are dimensioned in Table 1. Appendix (see page 90).

Sheet brass or copper of No. 10 gauge* should be used as the material with which to work, three thicknesses of which will produce a solebar-axleguard of a fraction under 2-mm. in thickness, which is correct.

The sheet should be stripped up into pieces ½ in. wide and then cut into lengths suitable for the wagon being made (see Table 1), after which the outline of the axleguards and the positions of the axle-holes should be carefully scribed on the face of one of the pieces. Every effort to obtain accuracy should be made, as this one piece can be made the drilling jig for the others. Should only hard-rolled brass be obtainable, the sheet must be annealed (softened) by heating it to red-heat and allowing it to cool slowly. This should be done before attempting to work on it.

After the scribing and marking-out has been done on the one piece, the axle-holes should be centre-popped, placing the sheet on a hard metal surface for the purpose. The two holes of the same size as that of the axles being used are then drilled. Do not try to drill with the "next size" larger drill, but *ream* out the same-sized holes until the axles are a smooth running fit.

Using the first plate as a drilling-jig, drill holes through the rest of the sheets, however many are required, and then thread them all on the drill (removed from the chuck) and place another similar

* Readers in possession of a micrometer, this gauge is equivalent to 0.026 in. Or, the thickness can be settled by making it that of the diameter of a No. 71 drill, or the diameter of No. 22 s.w.g. wire.

drill through the other hole. The stack of sheets may now be gripped in the vice and the corners soldered together (shown shaded), so that they may be filed to shape as one solid block of metal, and without bending.

When the laminated block has been perfectly fretted out with saw and needle-files, it may be held in the gas-ring until it falls to pieces, after which each piece must be cleaned up and all solder removed.

The solebar portion is then folded back over the two axleguards, shallow saw-nicks (*A*, Fig. 12B) being made in the upper edge of the solebar to allow the guards to fold over with the actual fold flush with the solebar upper edge. This fold must be made flush. No filing must be done to level it with the solebar upper edge, for the fold would be weakened thereby.

When as many of these units have been made as required, the relief appearance of the axleguards may be enhanced by cutting out the shape shown at *B*, in Fig. 12A (drilling and shaping it by the same method as that already described) and soldering it into place

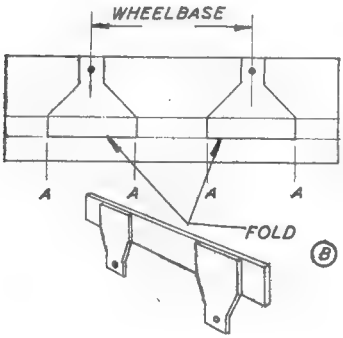


Fig. 12b. Solebar-axleguard

on the face of the solebar-axleguard unit. If desired the folded-over front of the axlebox may be left undrilled and form a real axleguard, but in actual practice the end of the axle will not be noticeable. Should the latter course be adopted, the front fold should be made before the axle-hole is drilled through both thicknesses of metal.

For the securing of accuracy during the soldering operation, the original (scribed) solebar-axleguard unit should be placed upon a level wooden surface and two fitting headless pins driven through the axle-holes into the working baseboard. The spring-axle-box units can then be slipped over the pins and held square with the solebar whilst soldering is taking place.

The assembly of two solebar-axleguard units and two headstocks to form a complete underframe

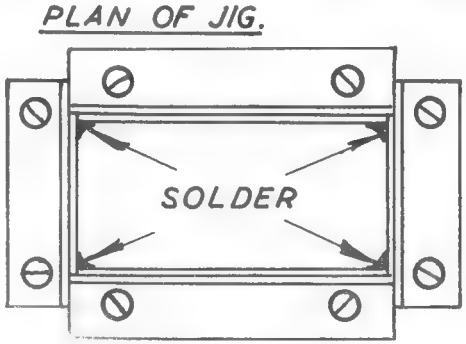


Fig. 13. Plan of jig

follows standard "OO" methods (Fig. 13). The headstocks should be drilled for buffers before assembly, the latter being made from ¼ in. round-

headed brass "pins," which are readily obtainable from most ironmongers.

The making of bogie side-frames follows much the same lines, but the two sides are assembled with a central stretcher (previously drilled for its pivot) instead of the two headstocks. A photograph of a four-wheeled bogie so made is seen in Fig. 14, in which spring-axlebox units have not been applied. It will be observed that their absence is not noticeable when the bogies are under a coach body.

Diamond-frame bogies may be made in the same way, working to axleguard outline only and soldering additional applique work on to their faces if desired. Only the slightest touch with a well-tinned and really hot soldering-iron is all that is necessary to effect a joint, the soldering being done on the rear face of the axleguard. There is, however, no fear of melting a casting, as is the case when soldering die-cast items.

The study of a large photograph of the solebar-spring-axlebox of a modern G.W. metal-underframed 13-ton wagon will, no doubt, suggest many other suitable methods of production which do not involve die-casting complications. For example, the axle-guards may be made up from No. 22 s.w.g. copper wire, bent round pins set in a baseboard to form a bending jig, and to this may be soldered a No. 10 B.A. brass nut, previously shaped to form an axlebox. The wire guard may be filed or hammered flat on its surface before the nut is soldered in place. The spring may be made in the same way from similar material.

Make certain that the axle-holes in the four axle-guards are all in the same plane, so that the vehicle

will stand four-square when placed upon a surface-plate of glass. Minor inaccuracies, though they may

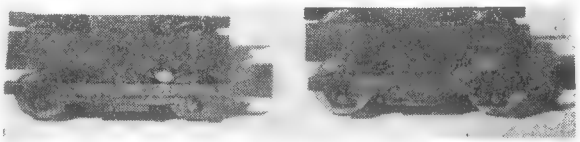


Fig. 14. Coach bogie

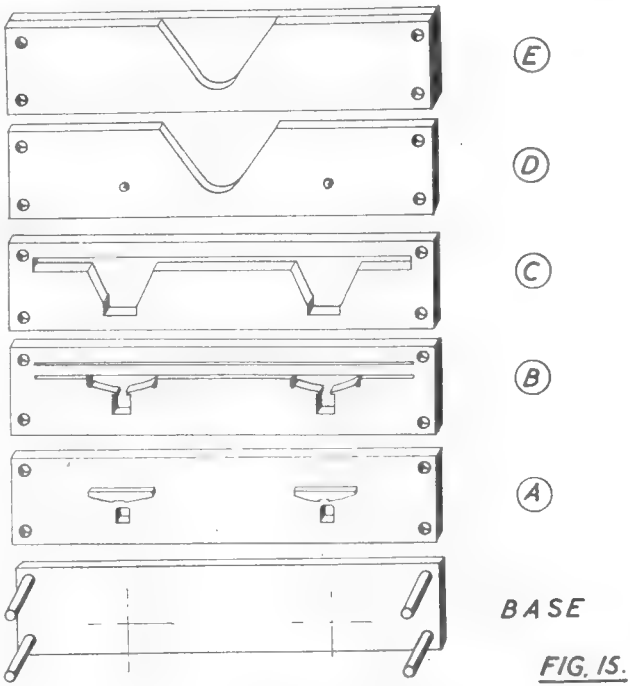


Fig. 15. Laminated axle-guard die

occur, will be hardly noticeable because any two discrepancies will be unlikely to be visible at the same time. If a vehicle "looks well" and runs well, then it will be a useful vehicle capable of taking its place in a train.

Returning to the construction and operation of laminated dies, a study of Fig. 15 will reveal that the die itself is composed of six sheets of metal, of which three (*A*, *B*, and *C*) are the most important, and which produce the shape of the axlebox, spring-solebar, and solebar axleguard respectively. These three sheets are made from No. 10 gauge hard brass (not softened), and are 0.66 mm. thick. All six plates are drilled at their corners to receive locating pins, which are screwed or riveted into the bottom blank plate (*O*), the other five plates having well-fitting clearance holes drilled through them. All the plates should be drilled separately, using plate "O" as a drilling template. Do not attempt to drill all at once.

After the locating holes have been drilled, a starting hole should be drilled in plate *A*, this hole being then opened and squared up to produce the die for the face of the axlebox. Plate *B* should then be placed on top of *A*—over the locating pins, and the square hole in *A* scribed on to *B*. Solebar and spring should then be scribed on to *B* and fretted and filed to shape. Plate *C* is then laid under *B*, the solebar outline and the spring being lightly marked on to its surface. The plate is then removed from the locating pins, and the grooves which will produce the axleguards are scribed on to its surface, using a small triangular file from which the cut has been ground off for the purpose.

If desired, these grooves may be cut with a fine saw, and the unwanted portions of the saw-cuts blocked up with wire after the cuts have been slightly undercut with a file. The writer prefers the deep-scribing method, as the copper wire insets are very apt to fall out of the die during the extraction of the casting.

A small piece of metal (*X*) must now be riveted to plate *A*, so that when *A* and *B* are superimposed, *X* fills the centre of the spring-gap in *B*. The rivets used for uniting these pieces may conveniently be short pieces of fine copper wire, which are pressed through holes in *A* which are countersunk on their underside to allow for clenching the rivets.

The bottom plate (*O*) is blank and forms the foundation upon which the other die-plates are superimposed. Plate *D* is also blank, save for the pouring hole and the "breather," and in it are fitted the marker pins for producing the centres for the axle-holes in the backs of the axleguards. These holes are better drilled than cast. Plate *E* has a channel cut on one side to form a pouring funnel, as shown.

The metal used for the production of the castings may be either lead or solder—the latter for preference—which should be melted first and cast into small sticks, which are then cut into lengths containing a little more metal than is needed for each casting. The laminations of the mould are then assembled, and held in a pair of pliers or a small hand vice. A wire plug is inserted in the pouring funnel hole to block the entry of the metal until it is really melted. When this has taken place the plug is withdrawn and the metal allowed to run into the mould until an overflow

at the " breather " hole denotes that the mould is full.

The metal flows from the bottom of the mould to the top, pushing out the air as it rises. The die is then set aside to cool after having been gently tapped while the metal is liquid to expel any occluded air-bubbles.

To extract the casting, plate *E* is first prised away from *D* (an old dinner-knife being perhaps the most suitable tool for the purpose) the strig of metal at the pouring-hole being cut through. Plate *D* is then separated similarly from *C*, taking care not to bend the axle-hole marking-pins. The removal of plate *C* from *B* will leave the casting fully visible, and it may be removed therefrom by the exertion of steady pressure, leaving only plate *A* attached by the axlebox.

If solder is used for the casting, it will not be found difficult to straighten up any slight bending that may have occurred during its removal from the mould.

It is very important that every pierced hole in the mould plates should have a very slight taper outwards from the lower side of the plate to the upper. This tapering must be carried out very carefully to avoid distorting the shape of the holes, and the correct amount of bevel can only be found by a process of trial and error when endeavouring to extract the casting from the mould. If extraction is found to be impossible, the only thing to do is to re-melt the metal out of the mould, take apart the laminations, and increase the amount of taper of the pierced work therein. The true art of die-casting depends entirely upon making a die from which a casting can be extracted without damage to either mould or casting ; the fulfilment of this requirement can well strain one's

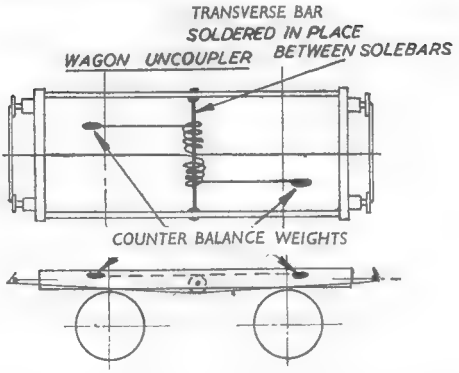


Fig. 16. Hooks and balance-bars

patience to breaking point. Die-casting is not by any means easy.

As to auto-couplings in 2-mm. scale, there is no doubt that the simple magnetically-operated system suggested to Mr. R. W. G. Bryant by Mr. Fleetwood Shawe* is the finest yet devised for the scale. The scheme is so simple that a diagram seems hardly necessary for it is only the old "bar and hook" method inverted, with the hook pivoted in the vertical plane. The hook is made of iron or steel wire, and the counterweight of brass or solder; normally, the hook stays up at the level of the transverse bar between the buffers. It couples on impact and is pulled down by a magnet located beneath the track—but only when the vehicle is stopped over the magnet or is being pushed over it. Uncoupling does not take place when a train of vehicles is being pulled over the magnet, because the bar on one vehicle holds the hook up on its neighbour. The hooks should be slightly

* See *Model Railway News*, December, 1949. With acknowledgments.

offset from the longitudinal centre-line of the vehicle so that there is no possibility of their fouling on curves.

Either permanent magnets may be used below the track, or a simple electro-magnet formed of 100 or so turns of No. 28 s.w.g. covered wire wound around a 1 in. countersunk iron wood-screw may be used. With such a magnet a single 1½-volt dry-cell would provide enough power and last quite a long time with normal usage.

The writer's arrangement for mounting the hooks and balance-bars to vehicles is shown in Fig. 16. It is not complicated to make, but works very efficiently in both 2-mm. and 4-mm. scales.

CHAPTER FOUR

THE BUILDING OF A " OOO " MOTOR UNIT IS NOT BY ANY means the extremely difficult job that might be supposed, and it is well within the capabilities of the average railway modeller who has had some experience with 4-mm. scale work. All the parts can be made without the use of an orthodox lathe, as any turning work can be effected with the aid of a small drill-brace rigged up horizontally in the vice.

Here is a list of the materials and, perhaps, unusual tools which will be needed in the construction of a 2-mm. motor :

1 ft. of $\frac{1}{16}$ in. or 3/32 in. round silver-steel (a No. 15 s.w.g. cycle spoke will serve).

6 in. of $\frac{1}{16}$ in. $\times$ $\frac{1}{4}$ in. silver-steel. (Such material may also be obtained from the handle-end of a keyhole saw.)

6 in. of $\frac{3}{16}$ in. o.d. thin-walled copper tubing. (This may be purchased at any garage under the name of petrol or oil piping.)

1 only 5/32 in. $\times$ $\frac{1}{2}$ in. Whitworth bolt.

1 sq. in. of $\frac{1}{4}$ in. thick Tufnol sheet. (This at the radio store.)

2 in. $\times$ $\frac{5}{16}$ in. No. 22 s.w.g. hard brass.

1 only 6-B.A. $\times$ 1 in. steel bolt.

1 only $\frac{1}{16}$ in. × 1 in. steel Whitworth bolt and nut.
2 10-B.A. × $\frac{1}{8}$ in. steel bolts.
2 6-B.A. lock-nuts.
1 second-hand (burnt-out) radio "output" transformer.
2 oz. reel No. 40 s.w.g. enamelled copper wire.
6 in. $\frac{1}{2}$ in. wide cellophane sticky tape.
6 in. No. 18 s.w.g. copper wire.
4 yd. No. 4 s.w.g. enamelled copper wire. (May be obtainable from the "output" transformer secondary winding.)

Tools :

$\frac{1}{16}$ in. twist drill.
10-B.A. tapping drill (No. 56).
10-B.A. clearance drill (No. 50).
6-B.A. tapping drill (No. 44).
10-B.A. middle tap.
6-B.A. middle tap.
3/64 in. to $\frac{1}{8}$ in. broach or reamer (taper).
Solder, soldering iron, "Eclipse" saw and two blades, drill-brace, small "Carborundum" slip-stone, and a small quantity of shellac varnish.

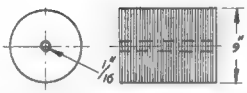


Fig. 17. Armature

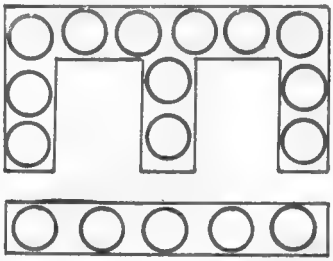


Fig. 18. Transformer core

THE ARMATURE

A start can be made on the armature, the dimensions of which (in millimetres) are shown in Fig. 17. The laminations may be cut from the "E" or "I" sections of the output transformer core, as shown in Fig. 18, if the sections are over 9-mm. in width; otherwise a piece of tinplate of the same thickness should be used.

As the possession of a lathe is not assumed, the circular armature laminations must first be cut and then finished to a round shape by working around a drilled hole in the centre of each piece. Therefore, either the transformer core laminations or piece of tinplate must be first centre-punched, and $\frac{1}{16}$ in. holes eventually drilled sufficiently far apart from each other to allow of small squares of sheet being cut—10 mm. square—with a hole in the centre of each piece. (Fig. 19.) Each square piece is then carefully

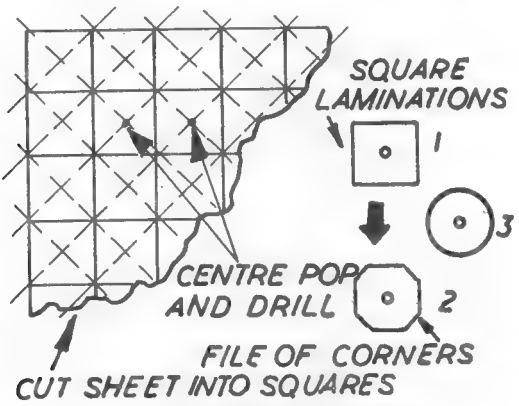


Fig. 19. Armature laminations

planished flat with a light hammer, working on a block of iron or at the back of the vice. All roughnesses around the drill-holes must also be rubbed down before assembling sufficient squares to make up the correct armature length of 9 mm.

Assembly is carried out by mounting a 3 in. length of $\frac{1}{16}$ in. silver-steel rod vertically in the vice (after trimming one end to a slight taper), and threading the squares on to the rod. When sufficient squares have been put on the rod, the batch is removed from the vertical position, and gripped in the horizontal (Fig. 20), taking care not to crush the laminated block in the process.

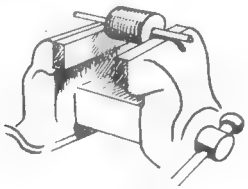


Fig. 20. Assembly

A smooth-cut file is then passed over the assembly in the direction of the arrow, thereby removing all the projecting angles of the sheets which, due to their irregular arrangement on the rod, will project in all directions—radially. The block of laminations should be turned until all the projections have been successively brought above the level of the vice jaws, and have been removed with the file, thus eventually producing an approximately cylindrical shape.

When a complete circuit of filing has been done, the block of laminations should be removed from the vice

and twisted round the spindle-rod at random. By this means any variations from the truly circular shape will be at once apparent, and another complete filing circuit is made as before, to remove the high spots.

A check must now be made for the correct diameter (9 mm.) and if the armature cylinder is of a *very* slightly larger size, the final finishing may be done in the hand-brace, which should be mounted horizontally in the vice to act as a lathe.

The now circular discs are next re-mounted on the $\frac{1}{16}$ in. Whitworth bolt, and its nut done up tightly, the whole being inserted in the drill chuck (Fig. 21). Whilst the drill is being steadily turned in the direction shown, the laminated cylinder is dressed up with the file until its diameter is exactly 9 mm., and it is truly circular in shape.

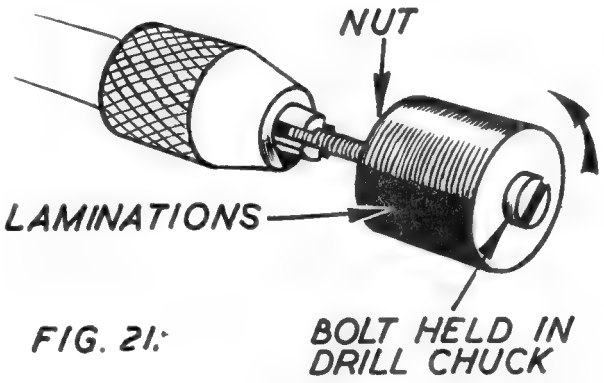


Fig. 21. Dressing laminated cylinder

MARKING OUT THE ARMATURE

The next job is that of marking out the cylinder into three sections, prior to the cutting out of the limbs of the armature ; owing to the small diameter of the latter, a special method of scribing must be used.

One of the end laminations from the stack is mounted by means of a drawing-pin in the centre of a 6 in. square of paper, centralising the lamination as perfectly as possible with the drawing-pin. (Fig. 22.) A 3 in. circle is then pencil-drawn with the centre of the drawing-pin as its centre, and a hexagonal figure is inscribed in the circle. Lines are then drawn from three equidistant angles of the hexagon, continuing them as scribed lines across the face of the lamination, thereby marking it accurately into three segments. Any slight error in the division of the circle will be

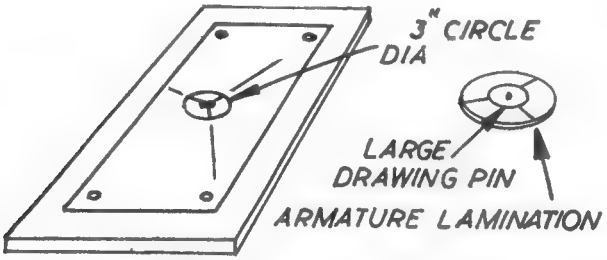


Fig. 22. Marking-out cylinder

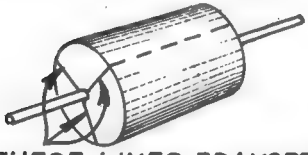


Fig. 22a. Marked disc

greatly reduced on the face of the lamination.

The marked disc is now removed and replaced on the cylindrical stack, and the scribed lines carefully transferred to the surfaces of the cylinder (Fig. 22A). Now, with the aid of a knife-edged needle-file, a groove is filed on each mark on the surface, so that a lead is given for the follow-up cuts made with an " Eclipse " saw.

The stack of laminations is gripped in the vice as shown in Fig. 20, retaining the $\frac{1}{16}$ in. bolt in place through the centre hole, and cuts 1, 2 and 3 (Fig. 23A) are made with the saw, great care being taken to ensure that it is held parallel with the axis of the cylinder and that the bottom of each cut is the same distance (" B ") from the centre hole. These three saw-cuts are followed by cuts 4 to 9 (Fig. 23B), taking the saw in each case in the direction of one of the previous cuts. Thus, cut 4 would be taken in cut 2, aiming towards the entry of cut 3 ; similarly, cut 5 would be taken in cut 3, aiming towards cut 2. Cuts 4 to 9 must be taken to an equal depth so that the webs (" A ") are left in place and are of the same thickness. Both ends of the armature must constantly be examined during the cutting process to ensure that the webs are not whittled away too fine.

When all the slots have been cut, and an equally-shaped armature has been produced (viewed from either end), two " Eclipse " saw-blades mounted side-by-side (and *not* in the saw-frame, but held by hand) are used to double the width of the six final cuts. This is shown in Fig. 23C, where the twin saw-blades are seen in the slots they have enlarged, and the

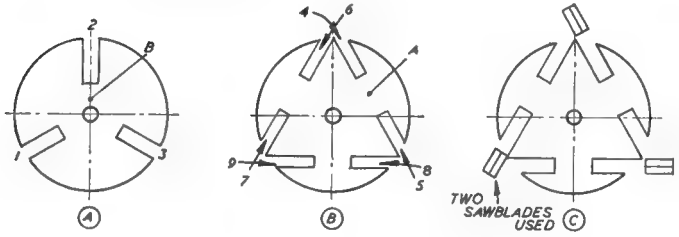


Fig. 23, A, B & C. Cutting out

Fig. 24. Cut-out "Armature"

remaining armature section is shown in solid black.

Now, with a flat needle-file, all the burrs and sharp corners must be trimmed from the edges and corners of the armature, so that the wire with which it has to be wound will not be cut thereon during the winding, which is the next job. The corners to which most attention must be given are shown heavily lined in Fig. 24, and very special care must be taken at the angles marked "X," round which the wire will pass whilst under tension.

WINDING THE ARMATURE

The armature must now be wrapped with a 3 in. length of cellophane adhesive tape, pressing it snugly into the first two winding slots with the back of a dinner-knife or some such blunt instrument, so that it appears as shown in Fig. 25.

Twenty-five turns of No. 40 s.w.g. enamelled

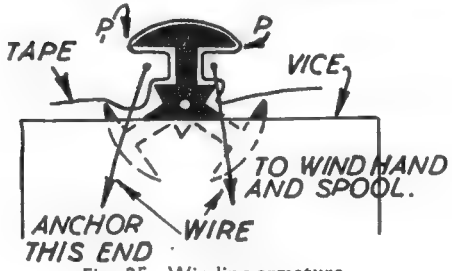


Fig. 25. Winding armature

copper wire are then very carefully wound in a clockwise direction round the first limb, taking great pains to get the first 5 or 6 turns right down into the bottom of the slot, and not allowing the wire to be jagged on the corners of the poles (*P*, Fig. 25).

When the twenty-five turns have been wound, the finishing end should be brought out at the same end of the armature as the starting end, and the last turn secured in place with a very tiny spot of sealing-wax, Chatterton's compound, or "Bostic." A 2 in. loop is then made in the winding wire, and the armature re-set in the vice so that the next limb (in a clockwise direction) is presented for winding. The projecting length of cellophane is then continued round the surface of the pole and snugly fitted into the next slot.

Leaving the looped wire projecting alongside the starting end of the first coil, twenty-five turns are wound on to the second limb, and the same processes of end-fixing, looping, insulation, and winding are carried out on limb three. The last turn of the third coil should be fixed in place and the end of the wire twisted up with the starting end of the first coil, as shown diagrammatically in Fig. 26.

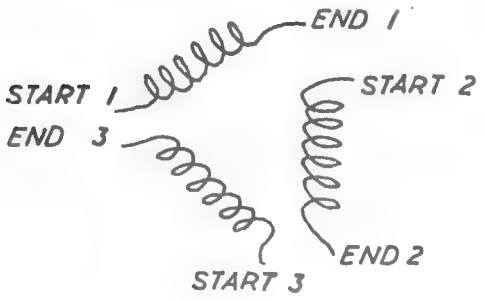


Fig. 26. Coils

Now lay all the twisted pairs of wire ends side by side, pointing out at one end of the armature, and carefully press down into the slots any slightly projecting coils, using the thumb-nail or a matchstick for the purpose. On no account use a metal object for this work.

A thimble-full of shellac varnish will be quite enough to allow the finished armature to be dipped, the centre bolt being slipped out before this process, as it would be impossible to remove the nut after the thread was choked with shellac. The wire ends will make a useful "handle" by which to manipulate the armature, and to remove it after it has absorbed as much varnish as it will take. The centre hole *must* be blown clear of varnish *before* hanging the armature up to dry by suspending it in a warm place by its wire ends, which may be bent into a hook-shape for the purpose. It is imperative that the drying armature is suspended with its axis vertical, so that the shellac drains equally into all three coils, otherwise a poor mechanical balance will result.

At least twenty-four hours should be allowed for drying, during which time the armature should not be touched. Then all visible cellophane should be extremely carefully cut away with a new safety-razor blade, great care being taken to ensure that the wire is at no time scratched or cut during the operation.

CHAPTER FIVE

MAKING THE COMMUTATOR

Whilst the armature is drying off hard, the building of the commutator may be taken in hand ; the successive stages in its construction are shown in Fig. 27, 1-7.

To make a start, a small piece of Tufnol, $\frac{3}{16}$ in. thick is approximately shaped into a disc with a diameter of about $\frac{5}{16}$ in., and at a point as near to the centre as possible, a centre-pop mark is made and a $\frac{1}{16}$ in. hole drilled through. The $\frac{1}{16}$ in. bolt used during the construction of the armature is then passed through the hole and the nut run up tight to the Tufnol, to form an arbor by which the disc can be mounted in the drill-chuck. Here its diameter is carefully reduced by filing with a flat needle-file until it *just fails* to enter the end of the copper tube, the bore of which must have all roughness at one end removed beforehand.

The ebonite centre, whilst mounted in the chuck, should now be reduced in length from $\frac{3}{16}$ in. to 5/32 in. ; each end should be countersunk as shown in Fig. 27 (3), and a piece $\frac{1}{4}$ in. long should also be cut from the prepared end of the 3 in. length of copper tube, the other end of which should have all roughness

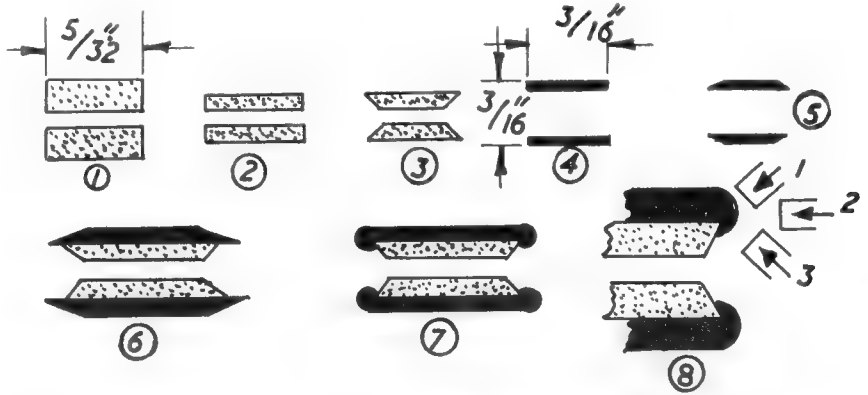


Fig. 27. Commutator

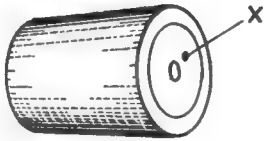


Fig. 28. " Tufnol " centre

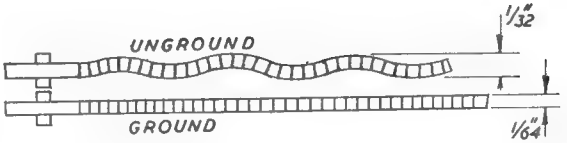


Fig. 29. Copper

removed from its bore. This short piece should now be examined through a glass to be certain that its bore is quite clean at each end, and should then be softened by annealing, bringing it to a bright red heat in a gas-fire and then plunging it into cold water.

This short piece of tube is now held in the drill chuck, and each end is chamfered off as shown in Fig. 27 (5), care being taken not to crush the tube in the chuck, for it is very soft.

Now re-chuck the ebonite and *very carefully* file it down (using the flat needle-file), keeping meticulously parallel, until a tight force fit can be made into the copper tube. When such a fit has been made, the $\frac{1}{16}$ in. bolt is removed, and the ebonite is forced into the tube, using the jaws of the vice as a press. The final setting shown in Fig. 27 (6) allows 1/32 in. of copper tube to overhang at each end of the Tufnol. It is most important that the fitting of the ebonite Tufnol into the tube is carried out without damaging the keen edges of the countersunk ends of the Tufnol.

The commutator is now chucked and gripped by one end, and the projecting end is very gently tapped over with a $\frac{1}{4}$ lb. hammer whilst the drill is kept turning, until the copper is wrapped inwards, embracing the edge of the countersink, as shown in Fig. 27 (7). This tapping should be very lightly done, and the copper "dressed" over until it is rolled right over the projecting edge of the Tufnol. The movements to be carried out with the hammer are shown in Fig. 27 (7), blows being given with the hammer successively inclined as shown and numbered "1," "2" and "3." The final shape and relationship

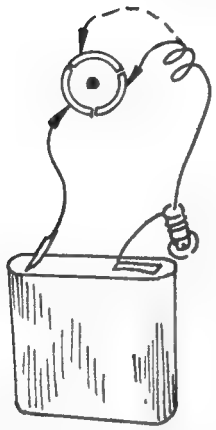
between the "Tufnol" and the copper are shown sectionally in the sketch (7).

After both ends of the commutator have been curved right over, and the "Tufnol" centre thus gripped, the commutator should be tapped finally with square blows, successively on each end whilst it is revolving in the chuck, until the copper ends are flat and at right-angles to the shaft and are not expanded enough to cover the centre hole ; there *must* be a gap between the copper and the hole, as shown at *X* in Fig. 28.

Now comes the delicate task of slitting the copper tube of the commutator into three equal segments, and for this a very thin saw will be needed. Such a tool can be made readily by grinding the "set" (wavy edge) from both sides of an "Eclipse" saw-blade (Fig. 29), which will produce a saw capable of giving a 1/64 in. wide cut.

The commutator is then threaded on a short length of $\frac{1}{16}$ in. rod and placed in the drill-chuck by gripping the wire. It is then pressed right up to the chuck jaws, so that slight nicks can be made accurately on the surface of the commutator at the exact points opposite to the gaps between the chuck jaws, these gaps being precisely 120 deg. apart, radially. The knife-edge needle-file should be used for the purpose, allowing its tip to enter the gap between the jaws of the chuck.

Follow this by placing the commutator and its temporary axle crossways in the vice-jaws, and grip it in the same way as the armature laminations were held taking the very greatest care not to crush the whole thing by using too great a vice grip. Next,



COMMUTATOR TESTING

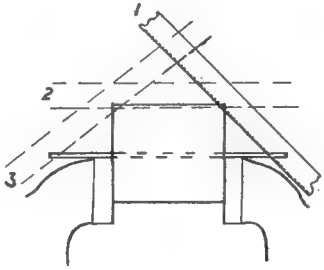


Fig. 30. Turning

Fig. 31. Testing

placing one of the three filed nicks uppermost, commence with the prepared saw, working first in the nick, and gradually levelling the saw, finishing on the corner nearest to you, as shown in Fig. 30. Extreme care must be exercised to cease pressure and cutting *the instant* the "Tufnol" centre is seen at the bottom of the saw-cut.

If the turning-over of the commutator ends has been carried out properly, the three slitting cuts can be made in the way outlined without the commutator falling to bits, and if all is well the turned-over ends can also be slit through so that each copper segment is completely isolated from its neighbours—and from the axle, as shown in Fig. 28.

The simple test set shown in Fig. 31 should now be made up, and each adjoining pair of segments touched with the test prods. At each test, the lamp

should *not* light. Next, one prod should be touched on the axle, and each commutator segment successively touched with the other prod. Again, the lamp should not light. If the lamp lights during any of these tests, then the offending gap must be cleared with the thin saw or the point of a needle. Should the axle be touching either one of the segments, then a $\frac{1}{8}$ in. drill, used between the thumb and forefinger may be used to clear away any minute excess of copper which must exist somewhere inside the turned-in ends of the commutator. As a final check, an eyeglass, used under a strong light will be found invaluable.

It is very important that all work on the commutator *must* be carried out very carefully and with extreme gentleness, otherwise the finished item will be rendered useless by fracture or even bursting. Try to bear well in mind that the commutator is *the* most difficult thing to be made in a motor—indeed, it may be said that it represents the most difficult task in " OOO " modelling.

THE ARMATURE SHAFT

The armature shaft is made from a piece of the $\frac{1}{16}$ in. silver-steel $\frac{15}{16}$ in. long, the ends of which are filed down to taper points with a 60 deg. angle, the drill being used for the purpose (Fig. 32). After rough filing, the points should be finished off with a very

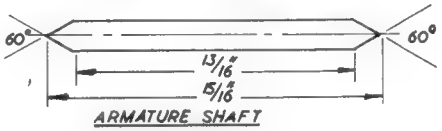


Fig. 32. Shaft

smooth file, and the shaft itself should be *very* slightly reduced in diameter with fine emery-paper until it will pass through the armature with the application of firm, but gentle pressure. Do *not* use force.

The taper points must now be hardened by being brought one at a time to bright red heat in a gas-flame and quenched in cold water—immediately, whilst red-hot. Only the extreme tips of the shaft should be thus hardened, and after tempering they should be honed with the carborundum slip-stone, being finally polished in the drill-chuck with a piece of "blue-back" (very fine emery-cloth), until both tapers are absolutely smooth, their points perfect, and truly concentric with the axis of the shaft, this last requirement being extremely important.

ARMATURE ASSEMBLY

The armature and commutator may now be assembled on the shaft, placing them as shown in Fig. 33, where it will be seen that measurement is taken from the rear-end, which should project about $\frac{1}{16}$ in. beyond the end of the armature.

If the shaft is gripped lightly in a vertical position in the vice, the wound armature can be pressed very carefully into the right position. A thin disc of paper is then threaded on to the shaft, and the commutator likewise "screwed" on until the washer is sandwiched into place. Care must be taken not to tangle up the three sets of projecting wire-ends in the process. Again, on no account use any force in these operations. At this stage assembly must remain, until the drive worm has been formed.

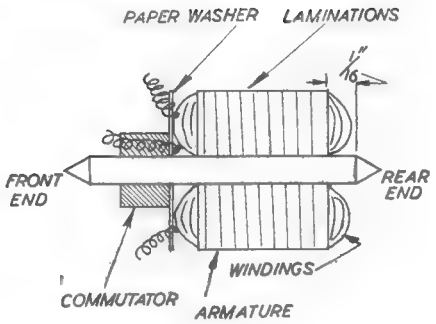


Fig. 33. Assembly

THE WORM

This is made from a $\frac{3}{16}$ in. length of the 5/32 in. Whitworth bolt, which is treated in the following manner :

Its head is first removed, and it is then gripped vertically in the vice, the jaws of which must be kept from damaging the thread by the interposition of two pieces of sheet copper or soft brass. The upper end of the bolt is then filed truly flat, and a centre-pop made as near to the centre as possible. In a lathe, this centring business is a simple matter, but in this case it is largely a matter of trial and error, centre-punching and re-filing off flat to a new surface until a punch-mark is made which is perfectly central. This can be proved by mounting the thread in the drill-chuck and turning, observing the while the behaviour of the punch-mark.

When perfection has been obtained, drill down into the bolt end (still in the drill-chuck, and holding the drill in a tap-wrench) with the No. 56 drill, taking a very light cut and using a spot of oil, until a depth of slightly over $\frac{3}{16}$ in. is reached.

Now cut off the $\frac{3}{16}$ in. length of bolt, and, mounting the No. 56 drill in the vice, spin the worm (piece of bolt) on it to see how it is for centrality of hole and freedom from wobble. If all is well, the hole should be opened up to a bare $\frac{1}{16}$ in. with the broach, keeping this tool vertical in all directions and working from both ends of the worm. On no account should an attempt be made to enlarge the original hole with the $\frac{1}{16}$ in. drill. The worm should be constantly tried on the shaft until a firm press fit is obtained, when it can be finally pressed on to the free end of the shaft until its outer side is $\frac{1}{16}$ in. from the commencement of the tapered end of the latter. When in place, it should be secured by a spot of shellac varnish applied on either side, between it and the shaft.

This completes the revolving part of the motor, and

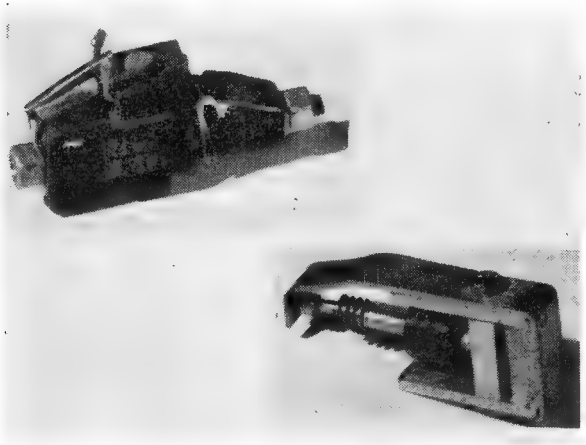


Fig. 34. Motors

a start can now be made on the magnet and armature bearings, the design of which is somewhat dependent upon the type of magnet to be used.

In the motors illustrated in Fig. 34, the writer produced a magnet from a piece of $\frac{1}{4}$ in. $\times$ $\frac{1}{16}$ in. tool steel $1\frac{1}{4}$ in. long which was softened, then drilled and shaped as shown in Fig. 35, being afterwards magnetised professionally at a magneto repair works. However, the magnetism did not last more than ten days, and another source of a suitable high-coercivity magnet was sought.

After much searching through war disposal stocks, a standard R.A.F. throat microphone* was found which yielded four $\frac{1}{4}$ in. $\times$ $\frac{1}{4}$ in. $\times$ 7/32 in. Ticonal magnetic blocks, two of which, placed end to end (north pole to south pole) fitted in nicely between the pole-pieces of the redesigned magnet as shown in Fig. 36.

The general arrangement of the new design is depicted in Fig. 36, where it will be seen that two pieces of $\frac{1}{16}$ in. $\times$ $\frac{1}{4}$ in. soft iron are bolted to a transverse brass block which carries the rear bearing of the armature-shaft, and are produced towards the rear of the motor so that they rest firmly upon the ends of the two magnetised blocks. A brass retaining hoop is fitted round the back end to retain the blocks in place, and a spot of solder is used to fix the blocks to the brass hoop, as shown.

This design entails a slightly greater projection of armature-shaft towards the front end of the motor, to

* These microphones are available in any quantities up to hundreds at Messrs. Franks Ltd., Oxford Street, London, W.C.

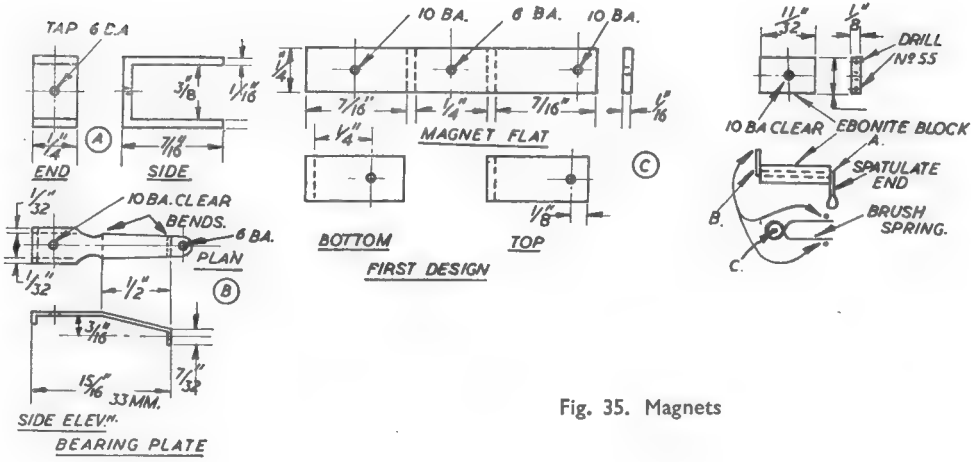


Fig. 35. Magnets

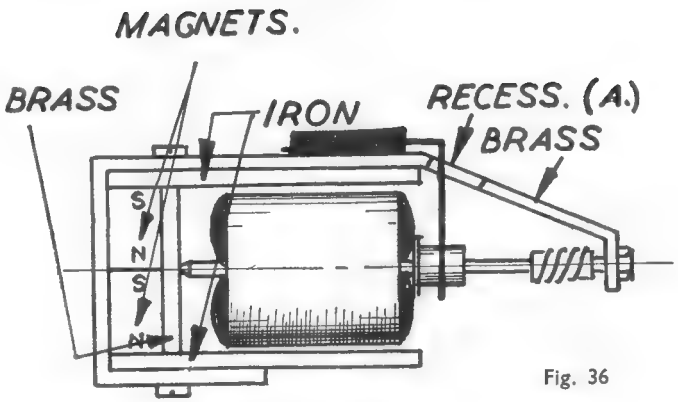


Fig. 36

SECOND DESIGN

allow for the additional thickness of the magnet blocks and rear bearing ; but if the latter is not made more than $\frac{1}{16}$ in. thick, the motor length will not be unduly extended. Generally, it is not motor *length* which constitutes a difficulty when fitting into a locomotive body, but its height and width.

A slight modification of the original front armature-shaft bearing was made so that it was continued in a rearward direction to wrap round the magnet blocks, but the two filed-out recesses (*AA*) were made to allow the brushes to rest upon the commutator.

The original brush-holder diagrammed was used, and this was made from a $\frac{1}{16}$ in. $\times$ 11/32 in. block of ebonite, " Tufnol " being found too flaky to be drilled with a No. 55 drill to receive the No. 18-s.w.g. wire from which the brushes were made.

For the brushes, two pieces of No. 18 tinned copper wire were used. These were flattened at one end to a

spade-shape and bent to a sharp right-angle at *A* (see Fig. 35), being then passed through the holes in the block and afterwards again bent at *B*. Fine twisted flexes were soldered to the rear end of the brushes to feed the current.

The brush spring consisted of a single strand of steel wire from a cycle three-speed cable. This was twisted into the shape shown and loosely secured to the brass bearing strip by a short No. 10 B.A. screw, a hole being drilled and tapped in the strip to receive it. This spring presses the two rear turn-ups of the brushes apart and at the same time equalises the pressure between them.

The motor will run easily on a potential of from 4 to 6 volts ; if a higher voltage is desired then the armature must be wound with more turns of a much finer wire than the No. 40-s.w.g. specified and the winding operation will be found well-nigh impossibly difficult.

A visit to the local watch repairer's provided the writer with a suitable wheel to mesh with the 32 T.P.I. worm one being chosen having 45 teeth thereby providing a 45 to 1 gear reduction. The wheel boss was then reamed out until a press fit was made on the engine driving axle to which the wheel was finally secured by a spot of solder.

The mounting of the motor between the locomotive frames followed normal "OO" gauge practice, a lug being provided at the front end of the frames to which the front motor bearing could be secured by solder when a perfect mesh had been found for the worm. A similar projection provided a means of attachment for the rear end of the motor.

As in " OO " practice, the main-frames were cut away slightly to clear the armature and brushes, and a stud collector shoe was fitted ; though, of course, if " two-rail " electrification had been used, the normal collection arrangements would have been fitted.

Finally, the reader is warned not to exceed the rated voltage of six with this motor, as rewinding the armature and soldering the wire ends to the commutator are not likely to be done for the second time without charring the commutator centre, converting it into a semi-conductor of electricity and thus putting the motor out of commission. Ample engine speed should be obtainable quite easily with a generous load from a 4 to 6 volt supply.

This motor has not been evolved to conform with any particular electrical standards (other than supply voltage) but to give a " between-frames " motor of the utmost simplicity which could be produced with average skill without a regular lathe, using only readily-obtainable materials. It will be appreciated that a set of ideals such as these were not easy to attain, but although, in absolute frankness, the making of this motor is no easy task, the reader can be sure of ultimate success if reasonable care and accuracy are the order of the day throughout the job—particularly during the winding of the armature. In this vital task, if a wire should break scrap the coil and start again. No. 40-s.w.g. wire cannot be joined by either twisting or soldering with success ; moreover, the joint takes up valuable room, and the added weight unbalances the armature a little at speed.

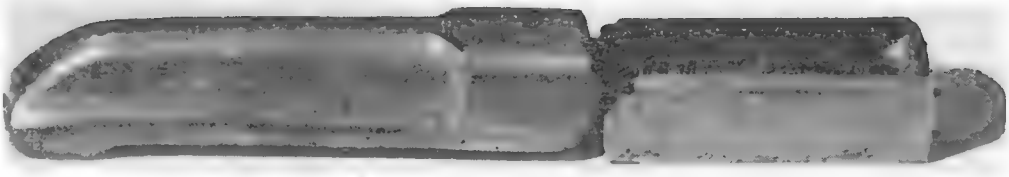


Fig. 37. Loco body cast solid in lead

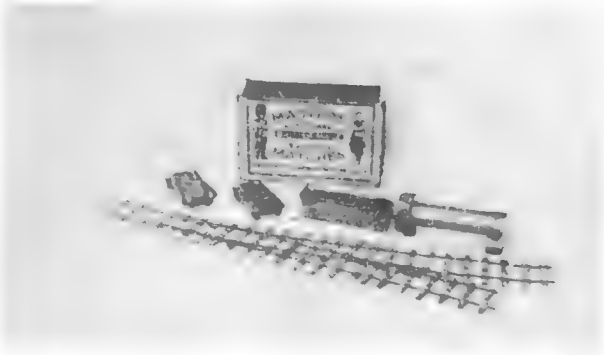


Fig. 37a. Comparison of size

CHAPTER SIX

IN ALL PROBABILITY THE MAJORITY OF READERS WILL have already had some practical experience of locomotive body building in 4-mm. scale, and have found that such work can be brought to a successful conclusion without any undue strain on either their skill, their patience, or their pocket.

What applies to 4-mm. scale is also true of 2-mm., and the truism that a model-maker's two finest tools are patience and care, is more than ever true in the smaller scale. Speed and skill will come with practice, and it is a good plan not to make a start on a large type of engine before some acquaintance has been made with the general technique of sheet-metal working.

It is impossible to stress too strongly the fact that a blueprint does *not* constitute the ideal source of building data, and should *only* be used in conjunction with photographs or measurements of the prototype itself. Moreover, if the blueprint and photographs are not of the identical engine, many inexplicable discrepancies of detail will almost bound to become apparent.

Squareness at all stages of construction, as well as absolute accuracy of measurement are the most

important prerequisites for the building of a successful locomotive body, and the slightest trace of slovenliness in the early stages of construction will be reflected throughout the whole job. Such early errors *cannot* be corrected during later constructional stages without a great deal of risk.

Most of the tools required for this part of "OOO" modelling will already be found in the average model-maker's kit ; thus any expense incurred in the purchase of specialised tools should be quite moderate.

Most important of all, a small piece of *plate* glass must be secured to serve as a surface-plate. No soldering work must be carried out on this, however, and a piece of truly flat board must be used as a work-bench, upon which parts may be joined by soldering.

A good steel rule, having the metric scale upon one of its edges is a necessity. It should be six inches in length and should be divided over at least part of its length into half millimetres. A "school ruler" is worse than useless. If a steel rule is used it will serve as both ruler and straightedge combined, and is thus useful for marking out sheet metal.

A pair each of flat-nosed, round-nosed, and side-cutting pliers are necessities, as well as a small hand drill and drills up to $\frac{1}{16}$ in. The smaller drills can be broken in half deliberately with advantage, and may be strengthened by slipping a small piece of cork over them whilst they are being used, allowing only $\frac{1}{16}$ in. to protrude.

A set of six needle-files is vital, as is a metal-cutting piercing saw and a dozen blades to suit it. A small $\frac{1}{4}$ lb. soldering bit, some solder and Baker's soldering

fluid, a small vice, a ¼ lb. hammer, and a small fretworker's clamp comprise all the vital tools.

If " tin-shears " or snips are already in the reader's tool-kit, it is most earnestly suggested that they are *never* used if the work can be done with piercing-saw or files. There is not any tool, the indiscriminate use of which by the amateur sheet-metal worker is more likely to bring about poor work. When shears are used, it should be with great discretion particularly when it is essayed to cut down straight lines or sharp corners. In both these cases their use is most likely to produce a wavy edge, and also to buckle the surface of the sheet metal in such a way that no amount of subsequent planishing with a hammer will completely remove the ripples.

For normal sheet body-construction, the thinnest of metal will be found extremely strong when made up into the small sizes required by " OOO " scale. Tinplate of No. 30 gauge (" I — C ") works quite nicely, and, moreover, a good supply of it is forthcoming from the air-seal lids of tins of tobacco. Of course German-silver or brass may be used if desired and if obtainable.

As the principles of locomotive body construction are so similar to those used in the larger scales—at least as regards sheet-metal work, it is not proposed to deal extensively with details in this book. The very fullest description of the methods used formed the subject of another work.*

However, it must be continually borne in mind that constructional errors and errors of measurement

* See " Locomotive Body Construction," Percival Marshall & Co. Ltd.

which would pass unnoticed in "O" gauge, and perhaps be passed in "OO," cannot be tolerated in "OOO" Where possible a 7-mm. blueprint should be used, and each measurement scaled down to 2-mm., thereby reducing the margin of error due to line thickness on the print to a minimum. The greatest of care must be taken also in the use of the dividers, and when scribing on to the metal.

In 2-mm. scale, in no case will it be found expedient to attempt to bend sheet metal into a sharp right-angled corner. A radius will always be apparent, for in this small scale, even a 1 mm. radius represents a 6 in. radius corner. Always cut and solder corners if a true sharp right-angle is required. There is no other way of doing the job.

The smaller the scale, the less detail is apparent, and in 2-mm. scale, it is a moot point whether the production of such details as rivet-heads and the like are worth while, even if capable of reproduction. It is more the general character of the prototype that matters, though of course, the greatest care must be taken to ensure that the profiles and contours of chimneys and domes are as accurate as is humanly possible ; for nothing does more to mar the effect of an otherwise good model engine than a badly-proportioned dome or chimney. On these items, due allowance must be made for the thickness of the subsequent coats of paint, which will thicken them up somewhat, and completely spoil an otherwise good profile.

There are, of course, other methods of locomotive body construction in 2-mm. scale, and one which

lends itself to the reproduction of streamline-type bodies is that of casting in lead, Wood's metal, or Rose's metal.

There are several substances which are quite satisfactory for the making of moulds for casting in such metals, and the most useful is plaster of paris. Hearth-stone and bathbrick, though quite suitable in a sense, are not capable of producing such a finely finished casting by reason of the natural coarseness of their grain.

To cast in plaster of paris, a tin with a hinged lid will be required, large enough to hold easily the body being cast. More than enough plaster to fill the box should be taken and mixed in a basin with water and a pinch of salt to a moderately stiff consistency, making certain that there are no lumps remaining in the resultant paste.

The mixing should be completed as quickly as possible, and the contents of the basin turned into the base of the tin, the surface being smoothed level with a wet table-knife.

The pattern body of the engine, carved out of candle-wax, or balsa wood, waxed, must now be pressed evenly and firmly into the plaster until it is half buried therein, with one complete side of the body projecting above the surface.

The plaster is now allowed to set naturally, being afterwards dried off in a gas oven with the gas turned very low, and after an hour or so the pattern should be removed from the lower half of the mould, thoroughly smeared with oil, and carefully returned into its original position.

Another lot of plaster is then made up and turned into the lid of the box, which is then brought over on to the lower portion and firmly pressed home into place, the excess plaster oozing from between the two halves of the mould. Setting and heat-drying then again should take place, after which the box is very carefully opened and the pattern removed finally.

As much of the oil as possible should now be cleaned off and "Vee-shaped" grooves neatly cut from the mould to the edge of the box. These grooves are made to allow the air to escape freely when the casting is being made, and they must on no account be omitted. A funnel-shaped groove must also be cut—half in the upper and half in the lower parts of the mould, to form a pouring point.

The metal may be melted in an old tin lid, one side of which has been bent out into a pouring spout. This should be handled with pliers, and the casting should not take place until the metal is thoroughly melted and hot. Do not attempt to pour immediately the metal has melted, but allow it to get really fluid.

After the pouring, allow about five minutes for the metal to set, and then prise open the mould, and carefully extract the cast body, taking great care not to damage the mould in case it should be needed by reason of the first cast not being perfect. The seam down the centre of the casting can be trimmed up with a sharp penknife.

On no account should the air-vents be overlooked; neither should the mould be used while moist, as casting would be positively dangerous.

Both Wood's and Rose's metal (which alloys have

very low melting-points) are ideal for the production of "one off" castings, for a suitable mould can be carved out by hand in hard toilet soap, which is neither too brittle nor too hard to work. Air vents and pouring funnels must be made, as in the plaster mould, but when working with bathbrick or hearthstone none are required, owing to the natural porosity of the materials.

Do not be discouraged if the first effort is unsuccessful, for it is well worth while to achieve efficiency, no expensive apparatus being required. Scrap lead may be obtained by the melting down of old wheels, etc., while Wood's and Rose's metals may be procured to order at the local chemist's store.

As has been mentioned, locomotive bodies of the streamlined type lend themselves particularly to casting methods by reason of their shape, which ensures the easy extraction of the casting from the mould without breaking the latter. With most normal engine types, however, the additional complication of the four-piece mould necessary to provide extraction would hardly be worth while, because it is quicker to build the body in sheet-metal in the normal way.

There is yet another method of producing these small engine bodies—that of electro-deposition of metal. This process is, in effect, that of electroplating a substantial layer of copper or nickel on to a wax or waxed plaster pattern, the latter being made of very slightly smaller dimensions than those required in the finished model.

The apparatus for depositing nickel electrically is neither expensive nor difficult to operate. The power

supply can consist of either a 6-volt, 100-ampere-hour accumulator (car type), or the rectified supply from the track terminals of the model railway eliminator can be used. In this latter case, if an ammeter is included in the eliminator, it can be used to regulate the supply to the plating vat in the ratio of 1 amp. to every 30 square inches of surface being plated. It will be realised that, as the surface area of the work under consideration will probably be under 6 sq. in., a current of about $\frac{1}{4}$ to 1/5 ampere will be sufficient, and within the capabilities of the railway power-supply.

A two-pound jam jar will serve excellently as a vat, into which the plating solution, composed of double sulphate of nickel and ammonia is placed. The strength of this solution must be that produced by $1\frac{1}{2}$ oz. of the chemical to every pint of distilled water, or rainwater, in the vat.

If the pattern locomotive body is carved from paraffin (candle) wax, it will be necessary first to oil it and then dust it with powdered plumbago or graphite ; the latter substance can be readily obtained from pencil lead, which should be finely crushed and sifted through muslin or a portion of rayon stocking.

The plumbagoed pattern is then suspended in the plating vat by means of two fine, bare copper wires, in such a way that it hangs equidistantly between two plates of nickel, placed one each side of it.

After being coated with plumbago, the pattern must not be touched by hand before being lowered into the vat, as any grease-marks will prevent deposition of nickel.

It will be noted that the pattern is attached to the

negative terminal of the supply (which must be direct current) and the two nickel anode-plates to the positive terminal. The vat will not work if these connections are reversed.

The surface area of each metal anode should be about equal to that of the pattern, and they should be placed as far from the pattern as possible within the jam jar.

The full output of the supply should be given to the vat for about 2 minutes, after which it should be cut down to $\frac{1}{4}$ to 1/5 ampere. No harm will result from the current being too low, but it must not exceed that stated if a good even deposit is required. The work should be left in the bath for at least 5 or 6 hours, according to the thickness of the film required.

When the depositing of the nickel is finished, the current is switched off and the body removed from the vat and thoroughly rinsed in running water. The wax pattern can then be melted out quite easily, leaving the shell of sheet nickel, which can be trimmed up with a file.

The production of outside motion-work in " OOO " presents many problems by reason of the extreme smallness and frailness of the parts, and the newcomer to the scale is advised not to attempt such work.

There are, however, one or two basic principles which must be observed in respect of such jobs. Small holes should always be drilled *before* shaping the material, e.g. Walschaerts valve-gear rodding. Small fittings should be shaped and soldered in place *before* being finally cut off from their " parent " stem of metal, which will act as a handle by which they can be manoeuvred into place whilst being soldered.

The beginner in 2-mm. scale will do well to realise *at the outset* that there are set definite physical limitations to his ideals in the way of reproducing super-details, and also that "effect" rather than slavish reproduction should be aimed at in this scale, which has—it is assumed—been followed because of its immense operational possibilities rather than for its super-detailed charms.

Most boiler-mountings can be turned easily in the hand-brace mounted horizontally in the vice, a selection of small gravers—ground to shape from broken-off drills mounted in handles—being all that are necessary in the way of tools.

The minuteness of these mountings permits of their being produced from very small pieces of brass. A 6-B.A. nut will supply all the material required for a G.W. safety-valve, and a chimney can be turned from a $\frac{3}{8}$ in. length of $\frac{1}{8}$ in. brass rod.

APPENDIX

TABLE I

DETAILS OF WAGON UNDERFRAMES

Drawing date	*Type*	*Wheelbase*		*Underframe length*		*Solebar depth*	
		Prototype	*2-mm. scale*	*Prototype*	*2-mm. scale*	*Prototype*	*2-mm. scale*
1923	12-ton metal underframe ...	9′ 0″	18	17′ 6″	35	9″	1.5
1923	12-ton timber underframe ...	9′ 0″	18	16′ 6″	33	12″	2.0
1932	20-ton standard timber u/frame	12′ 0″	24	21′ 6″	43	12″	2.0
1923	10-ton standard P.O. timber u/frame	9′ 0″	18	15′ 0″	30	12″	2.0

All details and dimensions are from official R.C.H. drawings.

TABLE 2

PLATFORM CLEARANCES

Platform Surface to underside of awning	19-mm.
Platform Edge to awning pillars	12½-mm.
Platform Coping overhang	2½-mm.
Platform Coping to nearside rail	6-mm.
Rail Surface to Platform Surface	6-mm.

TABLE 3

LOAD GAUGE AND MINIMUM STRUCTURE CLEARANCES

Minimum height above track of fixed structures	30-mm.
Maximum height of rolling stock above rail	27-mm.
Maximum heght of rolling stock to cant-rail	22-mm.
Maximum width of rolling stock	18-mm.
Maximum radius of roof arc. (rolling stock)	10½-mm.

TABLE 4

TRACK DETAILS

Gauge	9-mm.
Check-rail clearance (staight track)	0.625-mm.
Check-rail clearance (curved track)	0.625 + mm.
Sixfoot Way	18-mm.
Thickness of rail	0.017-in.
Gauge on sharp curves increased to	9.25-mm.
Sleeper size : 17 mm. long x 2 mm. wide	
Sleeper spacing	5-mm

BUFFER SPACING AND HEIGHT

Centres 7-mm. above rail level and 11½-mm. apart.

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